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ERTS: A PHOTOGRAPHIC DATA MANAGEMENT CONCEPT

TECHNICAL REPORT NO. 16
VOLUME III

JANUARY 1971
CONTRACT NO. NAS 5-10343

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EARL S. MERRITT
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prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

ALLIED RESEARCH ASSOCIATES, INC.
VIRGINIA ROAD · CONCORD, MASSACHUSETTS

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

REPLY TO ATTN OF 430.

April 6, 1971

Subject: "ERTS: A Photographic Data Management Concept", Technical Report No. 16, Volume III, Contract NAS5-10343, Allied Research Associates, Inc.

The subject report, attached, represents the culmination of a study effort begun in late 1969 to develop, independently, an approach to the problems of managing the potentially voluminous flow of data anticipated from the ERTS A-B satellites.

The anticipated data throughput requirements furnished this contractor as a basis for the study were different from those subsequently furnished the selected ERTS Ground Data Handling System contractor; thus differences exist in some of the assumptions discussed in this report and in information currently being released on the GDHS.

The attached technical report, as its title indicates, is one concept of an approach to a problem, based on assumptions clearly outlined in the report. This report is not to be construed as a definition of the ERTS data management procedures now being implemented by GSFC and the ERTS GDHS contractor.

J. Lindstrom
Technical Officer, NAS5-10343

Attachment

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FOREWORD

This report outlines a plan for the implementation of a photographic data processing, management and dissemination system to support the Earth Resources Technology Satellite.

It was prepared by the Geophysics and Aerospace Division of Allied Research Associates, Inc., under Contract NAS 5-10343 with the National Aeronautics and Space Administration and includes a portion of "Management, Processing, and Dissemination of Sensory Data for the Earth Resources Technology Satellite," Technical Report No. 11, Contract NAS 5-10343, December 1969.

Additionally, this report is the third of three related volumes. Volume I was entitled "Applications of Optical Processing for Improving ERTS Data" while Volume II was entitled "Use of Ground-Truth Measurements to Monitor ERTS Sensor Calibration."

The authors wish to acknowledge the cooperation of Messrs. J. Crawford and J. Helms of Allied Research Associates, Inc., whose contributions are included in Section 4, Appendix B and Appendix C.

ABSTRACT

Earth Resources Technology Satellite (ERTS) data rates and time lines coupled with user requirements are used to derive a development plan for the implementation and operation of a supporting photographic data processing, management and dissemination system. The plan specifies requirements for and phasing of facilities, equipment, personnel and operating procedures.

Major elements of the system are (1) an Initial Processing and Data Evaluation Activity, (2) a Photographic Production Laboratory and (3) a User Services Activity.

Initial Processing and Data Evaluation Activity functions include high-quality initial processing, quality control, monitoring, sorting and record-keeping.

The Photographic Production Laboratory provides bulk, special and precision processing; color compositing, and both archival and working storage.

User Services Activities accomplish montage and mosaic assembly, geo-scientific interpretation and consultation, classification and cataloging, and distribution.

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I. INTRODUCTION

The Earth Resources Technology Satellites (ERTS) will produce large quantities of sensory data. Most of these data will be disseminated to the various users in a photographic image format. In order to assure that these images are documented and distributed to users in a timely manner, a management, processing and dissemination system is required. Elements of such a system now exist at Goddard Space Flight Center. The Nimbus/ATS Data Utilization Center (NADUC) processes substantial quantities of sensory data produced by the ATS and Nimbus satellites. The NADUC is operated by Allied Research Associates, Inc., under contract to NASA/GSFC. The experience of planning and operating NADUC has provided a useful background for specification of an ERTS photographic data plan.

The following sections of this report define a management, processing and dissemination plan for the ERTS sensory data. This definition emphasizes the processing and related activities that occur after the data have been translated from an electronic signal into a latent image in a photographic emulsion.

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2. SYNOPSIS OF THE ERTS PHOTOGRAPHIC DATA MANAGEMENT PLAN

Elements of an ERTS photographic data design plan have been specified. Certain areas closely follow the data management system now being used for the Nimbus and ATS satellite systems (NADUC). Other areas have received extensive study in order to specify equipment, storage, user services, etc., to meet the special needs of the Earth Resources Program.

The plan details three major activities of the photographic data system. Planning for ERTS photographic data management has emphasized quality control. Each element in the system performs quality checking which must be completed before the data can proceed to the next element. In this way, the data quality is maintained, and expensive and time-consuming data reruns are reduced. Figure 2-1 and the following discussion provide a general overview of the proposed data system, facility plan, and the general data flow within the system. The assumptions and computed data rates are discussed in Section 3. The detailed specification of the data flow and processing at the intrafunctional level will be presented in Section 4.

The primary source of ERTS data entering the data system is from the NASA Data Processing Facility (NDPF). The functional elements of the data system include:

1) An Initial Processing Activity (IPA) which performs monitoring, accounting, sorting, initial high-quality film processing and evaluation to assure stringent quality control of all data distributed to the various user centers.

2) A Photographic Production Laboratory (PPL) which accomplishes all bulk and special (including color compositing) photographic processing. The PPL is a major activity of the Data Center and its specifications have, therefore, been emphasized in this report. Section 4.2 discusses the functional activities, a detailed facility plan, equipment and expendable materials for the PPL.

3) User Services Area - The User Services Area (USA) functions include:

a) Data Collation Activity (DCA) for shipping, receiving, duplicating, etc., services for the rest of the Data Center.

b) A Montage or Mosaic Preparation Activity (MPA) provides the space, equipment and personnel to assemble montages or mosaics of many of the ERTS photographs.

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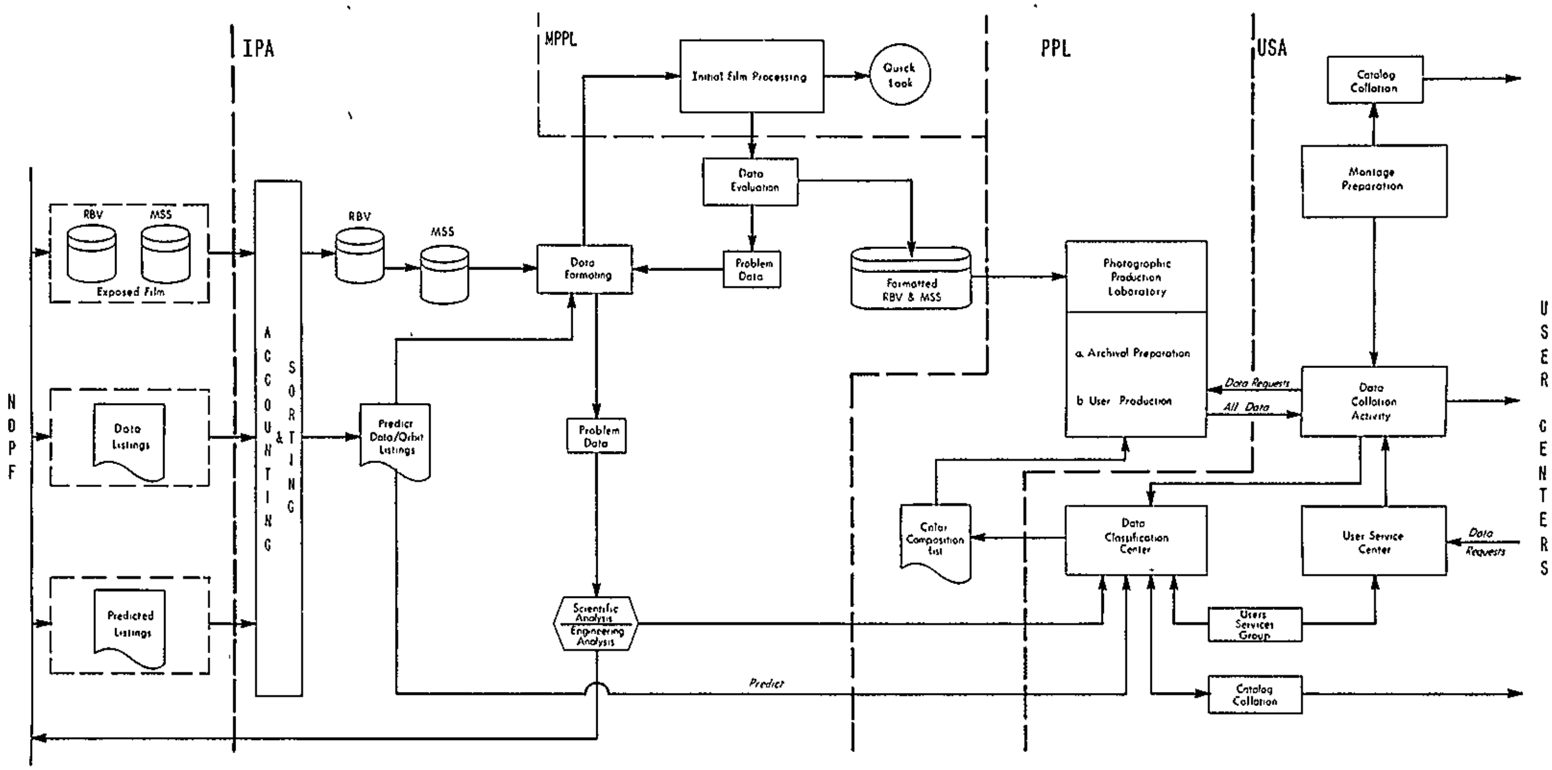

Figure 2-1 An Overview of the ERTS Photographic Data Management System

c) A Data Classification Center (DCC) where the information content of the imagery is examined and the cloud amount and atmospheric attenuation are measured and logged for inclusion in a Data Classification portion of the Data Catalog.

d) A cadre of geoscientists to support various data utilization experiments and data utilization directed experiments.

e) Preparation of a Browsing File. One set of RBV and MSS data in the form of positive transparencies will be prepared for the browsing file projectors in the User Service Center (USC).

f) Catalog preparation activity which prepares and regularly distributes ERTS data catalogs. These catalog and user's guides are detailed in Section 4.3.7 and Appendix A.

g) A data storage and retrieval library.

h) A User Service Center is proposed, where potential ERTS data users may direct inquiries, review the existing ERTS imagery, perform initial studies, etc. This center will provide the consulting services of the geoscientists resident in the DCC to users that require them. The User Service Center will also provide support to Mission Planning through evaluation of cloud cover information, predictions, etc., and development of sensor operation listings based on prescribed cloud thresholds. Section 4.3.6 describes the activities of the User Service Center.

3. ASSUMPTIONS AND CALCULATION OF DATA RATES, TIME LINES, MATERIAL COSTS AND STORAGE REQUIREMENTS

3.1 Basic Assumptions

In order to develop this ERTS photographic data plan, several important assumptions were necessary. The assumptions were based on engineering estimates available in late 1969* and are:

1) Two sensory systems will be flown on the early ERTS mission. The Return Beam Vidicon (RBV)** will operate in three separate spectral intervals producing three separate images for each shutter opening. The Multispectral Scanner (MSS) will operate in four separate spectral intervals producing four images of each scene viewed.

2) The ERTS orbit will be 497 n.mi. circular, polar, and sun-synchronous. The sensor field of view (100 n.mi.) will view the same area on earth every 18 days.

3) Initial ERTS missions will emphasize sensory coverage of the Continental United States. Global land coverage is, however, an eventual ERTS objective. (The estimates for space, equipment, personnel and expendable supplies assume an average of 13 minutes of sensor operation per day for U. S. Coverage*. Estimates are also included for an additional hour of taped data and for global coverage.) See Section 3.2.

4) Most of the ERTS sensory data will be mailed to the Data Center from various STADAN sites. Three to five days are expected for receipt.

5) The exposed unprocessed film will contain geographic grids presented as off-image tick-marks and annotations of time, principal point location, satellite identification and other appropriate information.

6) Bulk distributions will include 15 copies of 33 possible data sets for U. S. only coverage from the RBV and MSS sensor systems.

*More recent estimates of data loads indicate fewer copies of the sensor data, but additional imagery from the tape recorder. The result is that the decrease and increase nearly balance each other and do not materially affect the many computations carried out in this report.

**Appendix D presents a Glossary of Abbreviations citing the terms used in this report.

7) Routine distributions will provide 70 mm positive transparencies, 70 mm negatives, and 70 mm paper prints.

8) Estimated daily bulk distribution includes 1485 frames from the RBV and 1980 frames from the MSS for each of the three types of black and white routine formats. (Annual total bulk distribution, 3,800,000 frames for Continental U. S. coverage. Alaskan coverage will add about 30% to the total frames.)

9) Twenty percent of the production will be prepared as color negatives and prints. (No color transparencies were required in the 1969 engineering estimates.) Nine and one-half inch film formats were planned for color production. A total of 63 negatives and 315 prints per day were assumed.

10) Ten percent of the production will receive special processing. All special products were assumed to be on a 9-1/2" film format. One thousand, two hundred and sixty frames per day were assumed for the special production.

3.2 Data Rates and Time Lines

The following sections present information developed by personnel with more than five years experience processing meteorological satellite data in the Nimbus/ATS Data Utilization Center.

3.2.1 Daily Data Rates

The ERTS photographic data system will have certain specified requirements for timely data dissemination. The probability of achieving a given specification will be determined in part by the validity of the staffing, equipment and data rate estimates developed in this and subsequent studies.

On-Line Data Rates

The daily sensory data input for the United States and the world is defined in Table 3-1. Column headings indicate maximum pass time (MAX-T), minimum pass time (MIN-T), median pass time (median), average total number of RBV/MSS sets/pass, average number of sensory data passes per day, and total film footage* per day in either 70 mm or 9-1/2". A cloud factor multiplier is included

*This is the archival RBV and MSS data sets times seven channels. We assume 3.5" per data frame for 70 mm and 12" per data frame for 9-1/2". The extra length includes the annotation and the inter-image gaps.

TABLE 3-1

DAILY SENSORY DATA INPUT FROM UNITED STATES AND WORLD COVERAGE

Geographic Area	Orbital Sensor Operations							Cloud Factor
	Max-T*	Min-T	Median	Sets**/Pass	Average No. of Passes	Film (ft/day)***		
						70 mm	9-1/2"	
Continental United States	7.3	1	5.3	14	2.3	74	225	.40
Canada	8.0	1	5.5	15	3.0	100	345	.50
Greenland	7.0	1	5.0	14	1.4	49	137	.30
Central America, Mexico Carribean Islands	4.0	1	2.5	7	2.5	36	122	.50
South America	14.0	1	8.0	22	2.0	45	154	.50
Africa (including Arabian Peninsula)	20.0	1	13.0	35	3.0	71	245	.25
Europe (to 45E)	10.0	1	5.0	14	2.0	57	196	.55
Asia 45E - 90E (includes India)	18.0	14	16.0	44	1.5	135	462	.40
Asia 90E - 180 (not including SE Asia)	16.0	1	12.0	33	3.5	235	808	.40
Southeast Asia (includes Indonesia)	10.0	1	4.0	11	2.0	45	154	.65
Australia	8.0	2	5.0	14	1.5	43	147	.25
Alaska	3.0	1	2.0	5	2.5	25	87	.60
Antarctic	14.0	5	10.0	27	14.0****	(773)	(2646)	.65

*Maximum sensor operating time per orbit.

**Each set includes 7 channels of data.

***Daily film amounts are for master only (70 mm/9-1/2" x 9-1/2").

****Antarctic coverage is strongly redundant.

( ) 6 months only.

in the last column which indicates the percentage reduction in sensor operating time due to cloudiness in excess of 50% (a world average of 40% is anticipated). More sophisticated cloud amount simulation models exist and are recommended for use by ERTS planners*.

Table 3-2 presents the total daily film footage required for archival, routine production and 20% and 10% special processing for totally clear conditions over the Continental United States.

The on-line sensory data flow time lines for a single orbit sensor output over the Continental United States are presented in Figure 3-1. A first look at the full-resolution sensory display is possible approximately 30 minutes after the time the exposed undeveloped film is received in the Master Photographic Processing Laboratory (MPPL). The first delivery of a contact print for use in the IPA is about one hour and a half after receipt of film. The quality and standards checking will require about two hours, at which time the archival film is edited and spliced onto seven separate reels (by spectral band) with revised annotation if required. Approximately four and one-half hours after the film has entered the IPA functional area it is ready for routine photographic reproduction. Thus, bulk initial distribution of the black and white photographic products can occur in approximately nine hours after receipt of the original data at the Data Center. The color composite and special processed imagery will require additional time estimated at five to seven hours.

It appears that the planned ERTS orbital period of 103.5 minutes would permit reasonable sensory data handling for U. S. coverage even if the data were relayed to the Data Center in real time. However, in order to prevent nighttime and weekend data backlog, a seven-day week for the on-line activities is recommended.

Off-Line Data Rates

The "off-line" activities include Data Classification, Montage Preparation, and User Services. If color composites are to be prepared on a routine basis, a list of such data for all cloud-free images could be developed in IPA. This list could be delivered to PPL Job Control for routine processing.

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*"Worldwide Cloud Cover Distribution for Use in Computer Simulation," P. E. Sherr, A. H. Glaser, J. C. Barnes and J. H. Willand, 1968, NASA CR-61226, Allied Research Associates, Inc.

TABLE 3-2

TOTAL DAILY FILM FOOTAGE FOR ARCHIVAL BULK PRODUCTION AND SPECIAL PROCESSING

Initial Data		Bulk Production					Special Production						
		Black and White			20% Production Color Composite		Black and White				Color Composite		
	Archival Film	Positive Trans.	Negative Trans	Paper Print	Negative	Print	Archival Film	Positive Trans	Negative Trans	Paper Print	Negative	Print	
Acquisition Rate	Footage & Size (Master)	Footage & Size 15 Copies	Footage & Size 15 Copies	Footage & Size 15 Copies.	Footage & Size RBV 3 Copies MSS 6 Copies	Footage & Size RBV 15 Copies MSS 30 Copies	Footage & Size (Master)	Footage & Size 15 Copies	Footage & Size 15 Copies	Footage & Size 15 Copies	Footage & Size RBV 3 Copies MSS 6 Copies	Footage & Size RBV 15 Copies MSS 15 Copies	
RBV	29' 70 mm	435' 70 mm	435' 70 mm	435' 70 mm			3' 70 mm						
33 Frames													
99 Images	99' 9-1/2"	1485' 9-1/2"	1485' 9-1/2"	1485' 9-1/2"	21' 9-1/2"	105' 9-1/2"	10' 9-1/2"	150' 9-1/2"	150' 9-1/2"	150' 9-1/2"	12' 9-1/2"	60' 9-1/2"	
MSS	10' 70 mm	600' 70 mm	600' 70 mm	600' 70 mm			4' 9-1/2"						
33 Frames													
132 Images	132' 9-1/2"	1980' 9-1/2"	1980 9-1/2"	1980' 9-1/2"	42' 9-1/2"	210' 9-1/2"	14' 9-1/2"	210' 9-1/2"	210' 9-1/2"	210' 9-1/2"	24' 9-1/2"	60' 9-1/2"	

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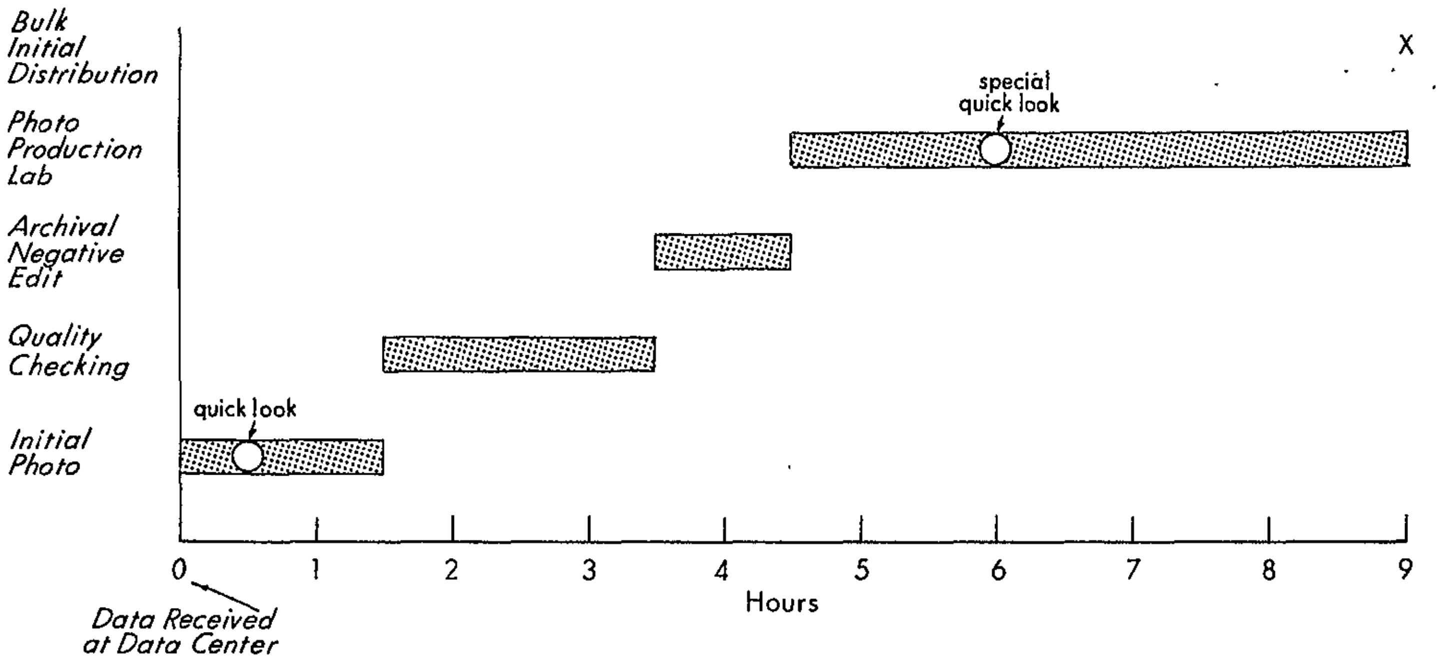

Figure 3-1 Sensory Data Flow -- Time Lines

3.2.2 Daily World Coverage Estimates

The time lines for world coverage would be quite similar to the United States Only coverage. However, approximately 560 sets of RBV and MSS imagery will be entering the system each day instead of the 33 postulated for United States Only coverage. Three shifts per day, seven days per week, operation will be required for all IPA activities, on-line and off-line. Staffing requirements would triple for the IPA activities but would quadruple, or more, in the Photographic, Data Classification and Montaging activities.

3.2.3 Annual Frame Amounts, Film Footage and Reel Requirements

3.2.3.1 Annual Frame Amount Assumptions (See Table 3-3)

1) Latitude limits for each zone are 60 miles beyond the north and south borders of the United States.
2) The first image set is recorded at the northern limit and one is taken every 90 n.mi. to the southern limit.
3) There are 20 ERTS coverages of the United States each year.
4) Forty-two (42) equally spaced data orbits are required for each U. S. coverage.

3.2.3.2 Film Footage Assumptions (See Table 3-3)

1) Each 70 mm RBV and MSS frame with annotation and interframe gap is 3.5".
2) Each 9-1/2" RBV and MSS frame with annotation and interframe gap is 12".

3.2.3.3 Film Reel Assumptions (See Table 3-3)

1) RBV and MSS imagery would be stored on separate reels by spectral interval.
2) 70 mm imagery would be stored on 500 ft reels.
3) 9-1/2" imagery would be stored on 250 ft reels.

TABLE 3-3

CALCULATIONS FOR ANNUAL FRAME AMOUNTS, FILM FOOTAGE AND REEL REQUIREMENTS FOR ONE YEAR'S COMPLETE U. S. COVERAGE

	Zones												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Latitude Limits	39. 6-48. 4	24. 0-46. 0	27. 0-44. 2	28. 0-47 8	25. 0-49. 0	25. 0-49. 0	28. 0-49 0	29. 5-49. 0	30. 5-49 0	31 5-49 0	33. 5-49 0	37. 0-49. 0	
Total Degrees	8 8	22 0	17. 2	19. 8	24. 0	24. 0	21. 0	19. 5	18 5	17 5	15 5	12 0	
Data Sets/Orbits	8	15	12	14	17	17	15	14	13	12	11	9	
RBV Frames/Orbit	24	45	36	42	51	51	45	12	39	36	33	27	
MSS Frames/Orbit	32	60	48	56	68	68	60	56	52	48	44	36	
Orbits/Zone/18 Days	4	3	4	3	4	3	4	3	4	3	4	3	
70 mm RBV													
Length/Orbit	13 ft	19. 1 ft	16. 5 ft	18. 3 ft	20. 9 ft	20 9 ft	19. 1 ft	18. 3 ft	17. 4 ft	16 5 ft	15. 6 ft	13. 9 ft	
Orbits/500 ft Reel	38	26	30	27	23	23	26	27	28	30	32	36	
Orbits/Zone/Year	80	60	80	60	80	60	80	60	80	60	80	60	
500 ft Reels/Year	2. 1=3	2. 3=3	2. 7=3	2. 2=3	3. 5=4	2. 6=3	3. 1=4	2. 2=3	2. 9=3	2. 0=2	2. 5=3	1. 7=2	36
70 mm MSS													
Length/Orbit	17. 3 ft	25. 5 ft	22. 0 ft	24. 6 ft	27. 8 ft	27 8 ft	25. 5 ft	24 6 ft	23 2 ft	22. 0 ft	20 8 ft	18 5 ft	
Orbits/500 ft Reel	28	19	22	20	18	18	19	20	21	22	24	27	
Orbits/Zone/Year	80	60	80	60	80	60	80	60	80	60	80	60	
500 ft Reels/Year	2 9=3	3 2=4	3 6=4	3. 0=3	4 4=5	3. 3=4	4. 2=5	3. 0=3	3 8=4	2 7=3	3. 3=4	2 2=3	45
9-1/2" RBV													
Length/Orbit	30 ft	51 ft	42 ft	48 ft	57 ft	57 ft	51 ft	48 ft	15 ft	42 ft	39 ft	33 ft	
Orbits/250 ft Reel	8	4	5	5	4	4	4	5	5	5	6	7	
Orbits/Zone/Year	80	60	80	60	80	60	80	60	80	60	80	60	
250 ft Reels/Year	10. 0=10	15. 0=15	16. 0=16	12. 0=12	20. 0=20	15. 0=15	20. 0=20	12 0=12	16. 0=16	12. 0=12	13 3=14	8. 6=9	171
9-1/2" MSS													
Length/Orbit	40 ft	68 ft	56 ft	64 ft	76 ft	76 ft	68 ft	64 ft	60 ft	56 ft	52 ft	44 ft	
Orbits/250 ft Reel	6	3	4	3	3	3	3	3	4	4	4	5	
Orbits/Zone/Year	80	60	80	60	80	60	80	60	80	60	80	60	
250 ft Reels/Year	13 3=14	20 0=20	20 0=20	20. 0-20	26. 7-27	20 0-20	26 7=27	20. 0=20	20 0=20	15 0=15	20. 0=20	12 0=12	235

4) Film would be organized and stored by zones.

5) There are either three or four data orbits per zone per 18-day coverage period.

3.2.4 Time Lines

Data Classification

Assuming the extremely limited type of cloud content and visibility obscuration classification, routine classification can be accomplished at a rate of 4 to 6 frames per hour. Therefore, a single orbit can be classified in 2-1/2 hours to 3-1/2 hours plus some setup time. As the classifier's experience level increases, this time may be reduced. Thus, two experienced image classifiers could keep up with the assumed United States Only inputs on a prime shift (8 hours per day, 5 days per week) basis. Monday morning would place them some hours behind, but they should be fully caught up by Wednesday of that week. Any slack hours in the last half of the week could be used to assemble the material for the Classification Catalog.

If the content classification concept discussed in Section 4.3.3.5 is introduced, additional image classifiers would be required since the classification time for one orbit is estimated at 3-1/2 hours to 7 hours.

Montage Preparation

The montage or mosaic preparation work would begin directly upon receipt of the imagery from the PPL. If a montage is prepared of the United States Only, no more than about 3 to 5 minutes will be required for each MSS or RBV image frame. Two montage technicians could, therefore, prepare all the required montages for the United States in a prime shift of 8 hours per day, 5 days per week.

Mosaicing

If some form of a true photographic mosaic is prepared on a routine basis, about four times the amount of manpower required for montaging will be required. However, if mosaicing is not a routine operation, but is rather a special request item, it is assumed that the two or possibly three montage technicians specified for the Montage Preparation activity could do an effective job.

Time Estimates for Color Compositing

The process of additive color printing from the ERTS multispectral imagery to produce color composites is time-consuming. Exposures must be made separately through three or four previously registered negatives and filters. Exposure times can exceed two minutes or more for each separation negative. This can be accomplished in an enlarger if 9-1/2" color products from 70 mm are being prepared. Direct contact printing would be used when using the 9-1/2" format directly. The total time per picture for either approach will probably exceed 10 minutes, even if we assumed automated means to achieve registration to within one picture element as specified.

An alternate, but highly recommended approach for routine color compositing, is through a system composed essentially of three or four projectors which have controllable filter wheels and output controls. A study of a potential color compositing system featuring 9-1/2" film plane image recovery is presented as Appendix C.

It is estimated that this type projection system could produce color composites, registered to one picture element, in at least a third of the time required for the manual approach.

3.3 Material Requirements and Costs

We believe that the quality of ERTS imagery can be maintained on 70 mm black and white film and print products. The proposed optical enlargement to the 9-1/2" size introduces fairly small (15 to 20%) resolution losses*. The 70 mm format offers an economical production operation and will provide a negative size that would be compatible with general photographic laboratory equipment.

The 10% precision imagery will be provided to users in a 9-1/2" format prepared by optical enlargement.

3.3.1 Film

In preparing costs for film materials we have based our estimates on the projected daily Continental United States coverage discussed in Section 3.1, Table 3-1. We have prepared estimates for production at 70 mm, 5" and 9-1/2" film. The special color and precision image output is all on 9-1/2" film size. Tables 3-4a, 3-4b and 3-4c provide estimated costs for U. S. Coverage Only with no reduction for cloud cover.

* A review of ERTS error sources and their relative magnitudes can be found in Reference 1 of Section 9.

TABLE 3-4

ANNUAL COST ESTIMATES FOR SENSITIZED MATERIAL

a. 70 mm size film*

Black and White	RBV (ft)	MSS (ft)	Total ft (ft)	Cost per ft ($)	Annual Cost ($)
Original 70 mm Film	10,585	14,600	25,185	06	1,511.10
Reproduction 70 mm Film	317,550	438,000	755,550	06	45,333 00
Print Production 70 mm Paper	158,775	219,000	377,775	03	11,333 25
10% Special 9-1/2" Film	131,400	165,200	296,000	18	53,388 00
10% Special 10" Paper	65,700	87,600	153,300	08	12,264.00
				Subtotal	123,829 35
Color					
10% Special 9-1/2" Film	4,380	8,760	13,140	.59	7,752.60
10% Special 10" Paper	65,700	131,400	197,100	32	63,072.00
20% Special 9-1/2" Film	7,665	15,330	22,995	.59	13,567.05
20% Special 10" Paper	114,975	229,850	344,825	32	110,344.00
				Subtotal	194,735.65
				Total	$318,565 00

b. 5" x 5" size film

Black and White	RBV (ft)	MSS (ft)	Total ft (ft)	Cost per ft ($)	Annual Cost ($)
Original 70 mm Film	10,585	14,600	25,185	06	1,511 10
Reproduction 5" Roll Film	550,500	712,700	1,263,200	09	113,688.00
Print Production 5" Roll Paper	273,750	351,350	625,100	.04	25,004.00
10% Special 9-1/2" Film	131,400	165,200	295,600	.18	53,388 00
10% Special 10" Paper	65,700	87,600	153,300	.08	12,264 00
				Subtotal	205,855 10
Color					
10% Special 9-1/2" Film	4,380	8,760	13,140	.59	7,752 60
10% Special 10" Paper	65,700	131,400	197,100	.32	63,072 00
20% Special 9-1/2" Film	7,665	15,330	22,995	59	13,567.05
20% Special 10" Paper	114,975	229,850	344,825	32	110,344.00
				Subtotal	194,735 65
				Total	$400 590 75

c 9-1/2" size film

Black and White	RBV (ft)	MSS (ft)	Total ft (ft)	Cost per ft ($)	Annual Cost ($)
Original 70 mm Film	10,585	14,600	25,185	06	1,511 10
Reproduction 9-1/2" Film	1,084,050	1,445,400	2,529,450	.18	455,301 00
Print Production 10" Paper	542,025	722,700	1,264,725	08	101,178 00
10% Special 9-1/2" Film	131,400	165,200	296,600	.18	53,388 00
10% Special 10" Paper	65,700	87,600	153,300	.08	12,264 00
				Subtotal	623,642.10
Color					
10% Special 9-1/2" Film	4,380	8,760	13,140	.59	7,752 60
10% Special 10" Paper	65,700	131,400	197,100	.32	63,072.00
20% Special 9-1/2" Film	7,665	15,330	22,995	.59	13,567.05
20% Special 10" Paper	114,975	229,850	344,825	32	110,344 00
				Subtotal	194,735 65
				Total	$818,377 75

* Estimates based on U S coverage only (an average of 12 minutes of sensor operation per day) If an additional hour of taped data is obtained the estimates shown should be multiplied by a factor of 5

3.3.2 Chemistry

The chemistry required for processing is, of course, a closely related function to film size. On the basis of the estimates of film and print material usage, presented in the previous section, we have prepared an estimate of chemistry costs for the 70 mm, 5" and 9-1/2" production. The estimated per foot chemistry costs are the best available at this time. In general, the estimates represent a median of the quotes received from the various vendors. Tables 3-5a, 3-5b and 3-5c provide per foot and annual cost estimates.

3.4 Factors Affecting Film Format Selection

The selection of an appropriate film format for the ERTS Data Center involves tradeoffs such as:

1) Quality and production
2) Handling and storage requirements
3) User requirements
4) Cost

Three film sizes are commonly used in aerial photographic mapping operations analogous to an ERTS mission. These are: 70 mm, 5" and 9-1/2"*.

Current state of the art in film manufacture can provide the resolutions appropriate to the ERTS imagery in any of these sizes.

The process handling of any of these film sizes is accomplished by automated systems. Therefore, on this basis alone, there is little reason to choose one size over another.

Storage volume of the 5" or 9-1/2" film compared to 70 mm is obviously a consideration. It becomes a major consideration with a volume-limited storage area. The ratio of 9-1/2" film to 70 mm film for storage is about 2-1/2 to 1. However, the ERTS Data Center is still flexible regarding storage areas. Section 4.2.12 provides an estimate of storage space requirements.

The cost of the film may be a significant consideration for the data quantities anticipated for ERTS. The cost of film and chemicals for one year of ERTS mapping of the United States is presented in Section 3.3.

*A 17" x 22" format for MSS display was investigated. Additional problems are created by this format and it is not recommended.

TABLE 3-5

ESTIMATED ANNUAL CHEMISTRY COST

a 70 mm size film

Black and White	Combined RBV and MSS Total (ft)	Cost per ft ($)	Annual Cost ($)
Original 70 mm Film	25,185	.008	201 48
Reproduction 70 mm Film	755,550	008	6,044.44
Print Production 70 mm Paper	377,775	003	1,133.33
10% Special 9-1/2" Film	296,600	022	6,525.20
10% Special 10" Paper	153,300	009	1,379 70
		Subtotal	15,284.15
Color			
10% Special 9-1/2" Film	13,140	.17	2,233.80
10% Special 10" Paper	197,100	.08	15,768.00
20% Special 9-1/2" Film	22,995	.17	3,909 15
20% Special 10" Paper	344,825	.08	27,586 00
		Subtotal-	49,496 95
		Total	$64,781 10

b 5" x 5" size film

Black and White	Combined RBV and MSS Total (ft)	Cost per ft ($)	Annual Cost ($)
Original 70 mm Film	25,185	.008	201.48
Reproduction 5"	1,263,200	.011	13,895 20
Print Production 5" Paper	625,100	005	3,125.50
10% Special 9-1/2" Film	296,600	.022	6,525 20
10% Special 10" Paper	153,300	009	1,379 70
		Subtotal	25,127.08
Color			
10% Special 9-1/2" Film	13,140	.17	2,233 80
10% Special 10" Paper	197,100	.08	15,768 00
20% Special 9-1/2" Film	22,995	.17	3,909.15
20% Special 10" Paper	344,825	08	27,586 00
		Subtotal	49,496 95
		Total:	$74 624 03

c 9-1/2" size film

Black and White	Combined RBV and MSS Total (ft)	Cost per ft ($)	Annual Cost ($)
Original 70 mm Film	25,185	.008	201 48
Reproduction 9-1/2" Film	2,529 450	.022	55,647 90
Print Production 10" Paper	1,264,725	009	11,382.53
10% Special 9-1/2" Film	296,600	.022	6,525.20
10% Special 10" Paper	153,300	009	1,379 70
		Subtotal	75,136.81
Color			
10% Special 9-1/2" Film	13,140	17	2,233.80
10% Special 10" Paper	197,100	.08	15,768 00
20% Special 9-1/2" Film	22,995	17	3,909 15
20% Special 10" Paper	344,825	.08	27,586.00
		Subtotal	49,496 95
		Total	$124,633 76

see footnote for Table 3-4

Users traditionally prefer the 9-1/2" size. Cost may well be a deciding factor in the final decisions; i.e., the United States is only a small percentage of the total earth, and global coverage is an ERTS design goal.

3.5 Precision and Special Processing Considerations

It is anticipated that the precision processing efforts will emphasize three areas.

First, significant nonlinear picture element displacements in the RBV or MSS electronic imagery will be corrected by appropriate digital processing. In addition to the rather straightforward corrections, such as line synchronization, bit loss, etc., a variety of photogrammetric transformations of the RBV data will probably be accomplished using the information inherent in the Reseau engraved on the vidicon screen. In the MSS processing, known attitude variation effects occurring during the scanning period can be removed by digital processing.

Second, the linear factors relating to image element location can be approached through optical processing techniques. Some applications of optical processing might include contrast enhancement of imagery which is otherwise clear but has a fairly high level obstruction to vision due to atmospheric turbidity. Optical approaches are similarly appropriate for noise removal. Further investigation of all the applications of optical data processing for the precision image processing is required.

Third, there are elements of photographic processing which are required for precision image preparation. These include optical rectification during processing, special exposure and development procedures for contrast enhancement, precise processing controls, etc. These corrections may be applied in the PPL.

4. PROPOSED ERTS PHOTOGRAPHIC DATA SYSTEM

The photographic data management system plan presented in the following section provides for efficient and expedient handling and processing of photographic products generated by the ERTS satellite. The essential elements of the system are:

1) An Initial Processing and Evaluation Activity (IPA) adjacent to the other activities of the NDPF in Building 23, Goddard Space Flight Center (GSFC). This is an on-line activity. A small high-quality, precision photographic processing laboratory, i.e., a Master Photographic Processing Laboratory (MPPL), should be considered as integral to the initial processing and data evaluation functions.

2) A User Services Activity (USA) which should be directly associated with the other NDPF activities in Building 23, GSFC, because of the need for close liaison between the users and operational control activities.

3) A Production Photographic Laboratory (PPL) off-site from Goddard in which all photographic production could be accomplished. The establishment of the ERTS PPL in Building 23 is not recommended because:

a) The projected growth of the ERTS production requirements.

b) The logistic problems associated with an upper story photographic laboratory; e.g., chemistry mix and replenishment using pumps is not a reliable approach.

c) The hazards of chemical spill to computers, equipment, etc., on floors below necessitate expensive floor construction.

The discussion of these elements has been divided into three separate sections for clarity. Section 4.1 presents a discussion of the Intial Processing and Data Evaluation Activity and Master Photographic Processing Laboratory. Section 4.2 presents the details of the facility, equipment, etc., for the Photographic Production Laboratory. Section 4.3 discusses the User Services Activity. The important overall considerations of quality control transcend any specific element of the management system and is, therefore, discussed separately in Section 5.

4.1 Initial Processing Activity (IPA)

Figure 4-1 presents a detailed functional data flow plan for IPA. Three types of data enter this activity:

1) Exposed unprocessed RBV and MSS photographic film records.

2) Computer listings presenting all the annotation information (frame time, data, principal point) contained on the RBV and MSS film records, the pertinent orbital information and any available calibration information and identification of the magnetic tape which contains the imagery.

3) Records obtained from the data collection subsystem (DCS).

4.1.1 Accounting and Sorting (A&S)

These input data pass through an Accounting and Sorting (A&S) function. The A&S personnel should have received a listing of the anticipated input data very shortly after the data have been acquired by the readout site (this may be 3 to 5 days before the actual data reach A&S. The actual data received can then be checked against the previous listing and a master procedures listing. A&S personnel should thus be fully aware of the amount, format and subsequent internal distribution of the data. Any differences between the data anticipated and that received should be checked prior to further distribution within IPA. An uncorrected disparity should be logged and the IPA supervisor notified.

4.1.2 Annotation Monitor (AM)

The AM will compare the orbital program information with the actual data listings. He will verify:

1) Orbit number (sensory and acquisition)

2) Number of frames (or minutes) of data for each sensor

3) Sensor operation times

4) Locations of the geographic grid points in relation to predicted locations.

Figures 4-2 and 4-3 present examples of the types of information and data logging files proposed for use by the AM.

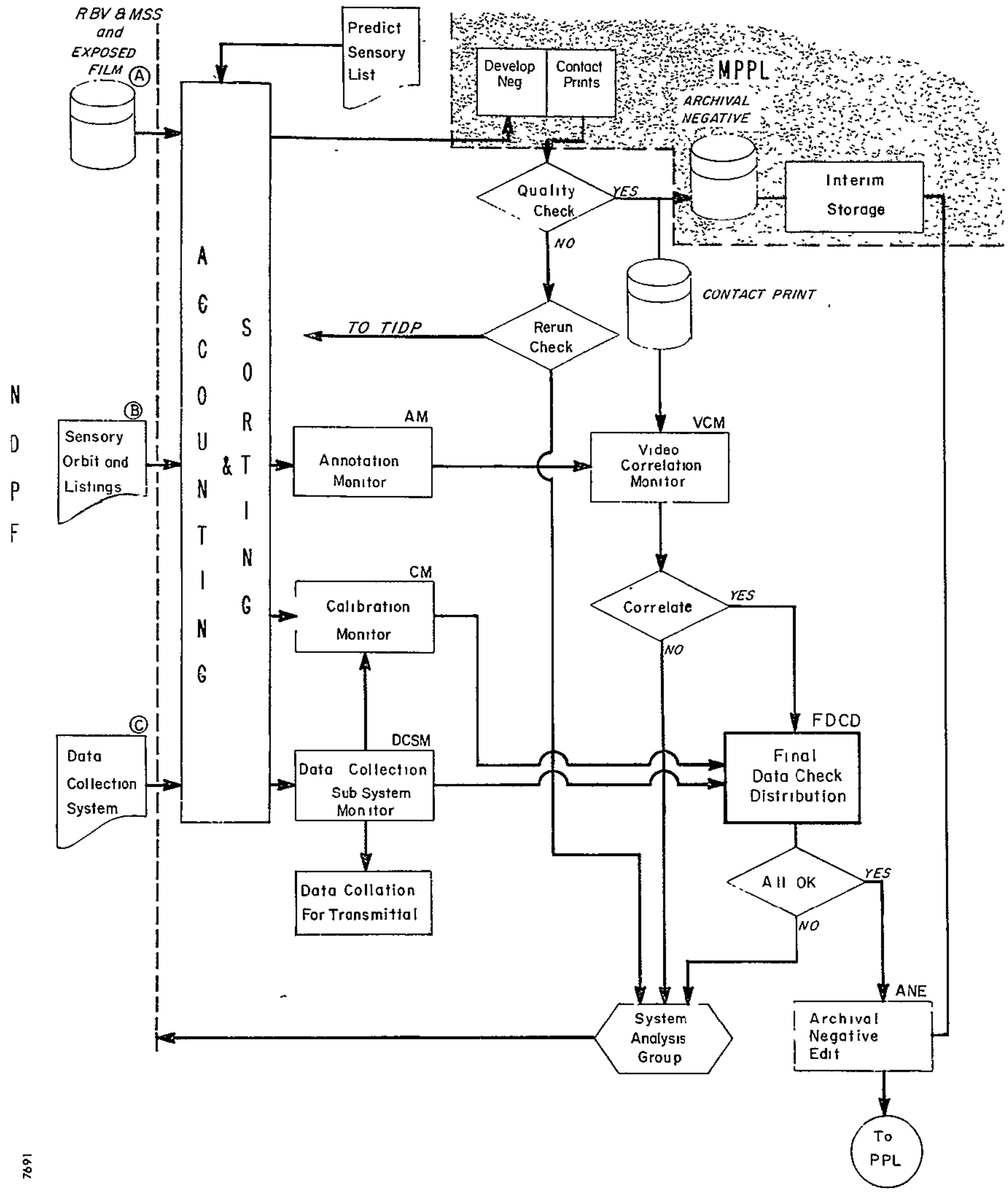

Figure 4-1 Initial Processing and Evaluation Activity

ERTS 1
ANNOTATION MONITOR LISTING

Sensor Sampling Orbit; ______ Day ____ Month ______ Year ______
Stadan Acquis. Orbit; ______ Day ____ Month ______ Year ______
Stadan Acquis. Site, ______ Start Time, Ut ______ End Time, Ut ______

Number of RBV Frames C_1___ C_2___ C_3___ , Time Span of MSS #1 ______ #2 ______ #3 ______ #4 ______

ORBITAL ELEMENTS	
Predict ☐	Definitive ☐
Epoch ______	
Identifier:	Run Date/Time ______
Validity Period ______	

TAPE IDENTIFICATION & FILE LOCATION	FRAME No. RBV	CAMERA No.	EXPOSURE TIME GMT HH MM SS	IMAGE PRINC. POINT LAT. LaLa. LaLa	LONG. LoLoLo. LoLo	SAT. SUB-POINT LAT. LaLa. LaLa	LONG. LoLoLo. LoLo	CALIBRATION DATA RAW	PROCESSED
	1	C-1							
		C-2							
		C-3							
	2	C-1							
		C-2							
		C-3							
	3	C-1							
		C-2							
		C-3							
	4	C-1							
		C-2							

NOTE: Repeat this Format for Each Set of Frames Sampled on Different Orbits But Acquired During a Given Stadan Interrogation

TAPE IDENTIFICATION & FILE LOCATION	MSS	CHANNEL	START TIME OF SCAN HH MM SS	END TIME OF SCAN HH MM SS	GRID ANNOTATION MARKS TIME UT HH MM SS	LAT LaLa LaLa	LONG LoLoLo. LoLo	CALIBRATION DATA RAW	PROCESSED
	Span 1	#1							
		#2							
		#3							
		#4							
	Span 2	#1							
		#2							
		#3							
		#4							
	Span 3								

NOTE: As Many Lines as Necessary for Grid Annotation Marks for Each Channel.

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Figure 4-2 Data Logging Form for Use by the Annotation Monitor

ERTS 1
EQUATOR CROSSINGS
NORTH AND SOUTH BOUND

ORBITAL ELEMENTS
Predict ☐ Definitive ☐
Epoch ____
Identifier: Run ____
Date/Time ____
Validity Period ____

PART A (STANDARD)	ASCENDING NODE LONGITUDE DEG	ASCENDING NODE TIME HH MM SS		ORBIT		DESCENDING NODE LONGITUDE DEG.	DESCENDING NODE TIME HH MM SS	DATE DAY MO YR.
				1				
				2				
				3				
				4				
				5				
				6				
				7				
				8				
				9				
				10				
				11				
				12				

PART B ORBITAL EPHEMERIS AS A FUNCTION OF START TIME AND TIME INTERVAL (OPTIONAL CALL)

NOTE: A. If no start time is given as input then always start at the equator crossing (ascending or descending to be specified in the future.)

B. If no time interval is specified then the time interval will be at a specific number (to be specified in the future) The non specified time interval will probably be the same as the RBV shutter exposure time interval sequence

C. Orbital ephemeris program to have the capability of running through two complete orbital periods plus 5 to 10 points into the third orbital period computation.

START : Time or orbit number or preset

END : Time or orbit number or preset

TIME INTERVAL: Preset or variable value Input

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Figure 4-3 Orbital Listing Format Supplied to Quality Assurance from T&DS

4.1.3 Master Photographic Processing Laboratory (MPPL)

The primary responsibility of the MPPL is the high-quality processing of the film exposed in NDPF and the preparation of a single black and white contact print to be used in the IPA monitoring activity.

The master negative will be used to produce one or two contact positives (hard copy prints seem to be adequate at this time). Following production of the contact positives, the master negatives will be packaged, sealed and placed in an interim hold area.

Any variation in the standard of image quality noted in the MPPL will require corrective action. If the data prove questionable, notification will be provided to all other DCA activities to hold further action until the corrections are completed.

It is strongly recommended that the MPPL not be combined with the many varied duplicating film chemistries that must be associated with the Photographic Production Laboratory. Only through isolated control of raw data can accurate and valid interpretation be guaranteed for engineering assessment of the ERTS sensors and display systems. Therefore, a separate MPPL activity, where extremely precise processing controls and extreme cleanliness are maintained, is recommended.

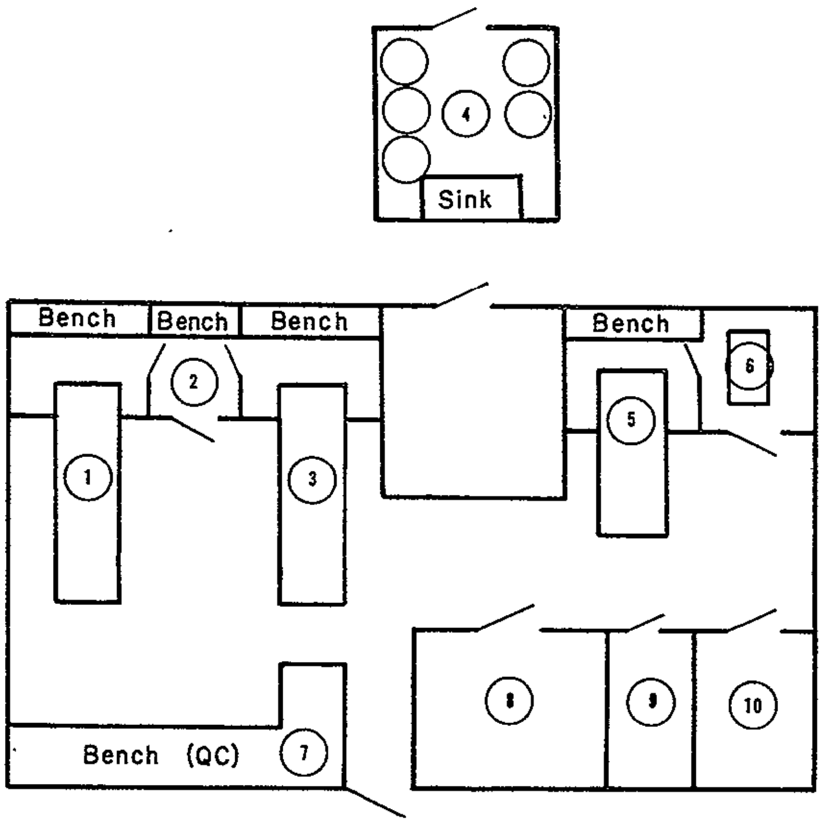
Quality control during photographic production is of sufficient importance, such that it is described separately in Section 5.

<u>MPPL Facility Plan</u>

Figure 4-4 presents a proposed MPPL. IPA functions should be placed adjacent to the MPPL facility (see Reference 1 in Section 9). The chemical mixing area is shown on the same level as the processing laboratories. A two-level concept is to be preferred but the small size of the PPL mix and store area may not justify this approach. If the area is placed on the same level, it should be isolated from the remainder of the laboratory; i.e., sealed walls, separate air-conditioning system, and separate drainage.

<u>Sensitized Material Storage</u>

When films are intended for critical use, requiring uniform results, certain storage criteria must be maintained. No color materials are required for the MPPL; therefore, control capability to 40^{o}F and relative humidity to 40% will provide ideal storage conditions for materials to be used within one year.



Legend

(1) Automatic Film Processor
(2) Sensitometric Exposing Room
* (3) Automatic Film Processor
(4) Chemical Mix and Storage Room
(5) Automatic Paper Processor
(6) Continuous Strip Paper Printer
(7) Quality Control Instrumentation
(8) Editing and Splicing Room
(9) Archival Film Storage
(10) Black and White Sensitized Material Storage

* Back-up only if received in 9-1/2" format

Figure 4-4 Proposed Floor Plan for the Master Photographic Processing Laboratory (MPPL)

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4.1.4 Video Correlation Monitor (VCM)

Data arrives at the VCM from two sources: the MPPL and the AM. (Contact positive copies of the RBV and MSS imagery come from the MPPL and the data listing logs from the AM.)

The contact positive copies are spliced into separate swaths for each of the three RBV and four MSS channels for the guidance of the Archival Negative Edit (ANE). The annotation presented in each frame will be compared with the listings received from the AM. Corrections will be established and flagged for mannual entry onto the master negative during final data package assembly. (Appendix B discusses and recommends a manual annotation system.)* If all annotations check satisfactorily, the data package can be released to the Final Data Check/Distribution (FDCD) activity.

4.1.5 Calibration Monitor (CM)

The CM will continuously monitor the performance of the sensors relative to the prelaunch expectancy. In general, this will require review of the display voltages, and the critical elements of the sensor package such as detector temperature, etc. An important element to be accomplished in the CM area, is the routine evaluation of noise which may be introduced into the imagery from a variety of sources from satellite components to ground display. We suggest evaluation of the white noise spectrum through application of optical data-processing techniques. The diagnosed noise spectrum could be used to derive special filters for use in improvement of the digital sensory data.

4.1.6 Data Collection Subsystem Monitor (DCSM)**

The DCSM is responsible for the collection, monitoring and dissemination of the data collected by the DCS. Two types of data may be available:

1) Data which must be relayed to users in near real time; e.g., snow cover, stream flow, etc.

2) Data provided for assisting in the sensor calibration function of the CM.

*If manual correction is not possible, a display rerun may be required.

**In practice, the CM and the DCSM may be combined into a single function.

When any of these data contain designated ground-truth information, a copy should be relayed to the FDCD for inclusion in the appropriate frame annotation. Figure 4-5 presents a possible listing format for use by the DCSM.

4.1.7 Final Data Check/Distribution (FDCD)

Arrival of the complete data package (from VCM, CM and DCSM) in the FDCD signals the beginning of the final QA&S task. The FDCD will insure, by thorough checks, that the picture times, grid points and annotations are internally consistent. Items which were flagged in earlier phases of processing should be corrected. Any significant flagged items which cannot be easily rectified should be referred to the Systems Analysis group for analysis and corrective action.* As soon as total data package integrity is assured, the master contact positive is sent to the archival film edit activity.

4.1.8 Archival Negative Edit (ANE)

The ANE activity prepares the archival negative for subsequent photographic reproduction. The processed master negatives have been retained in an interim hold storage until this time. The ANE facility should be arranged so that the environmental requirement for interim hold storage and ANE can be met with a single environmental filtering system.

The ANE receives a "clean" copy of the mockup format. Facilities must be available to revise the annotation,** add appropriate calibration information and label the film strips.

Equipment requirements for the ANE include viewers, automatic splicers, an annotation imprinting system, etc.

Following completion of the negative edit, the archival film is placed in cans and sealed. The cans and the mockups are returned to FDCD for transfer to the Photographic Production Laboratory. A final check for total package integrity should be conducted before the data package is released to the PPL.

---

*Annotation revisions will be indicated.

**A study of manual annotation systems (including a recommended system) is included as Appendix B.

ERTS 1
DCS LISTING

TAPE IDENTIFICATION & FILE LOCATION	PLATFORM IDENTIFIER	PLATFORM LOCATION † LL.LL III.II	USER	MODE OF DISSEMINATION	DISSEMINATION ADDRESS	PRIORITY	CALIBRATION AND/OR GROUNDTRUTH DATA	ACQUISITION INFORMATION	
								ORBIT	TIME
	α	38°N, 128°E		Mail	Mr. John Doe, Dept. A3 U. of America 5 Smith Ave. Millsburg, Arizona 20579	Two Weeks			
	β	61°N, 98°W		TTY	XC-473-A5	Near Real Time	Yes		
	γ	48.215°, 32.33°W		Phone	(212) 578-0938	Near Real Time	Yes		
	δ	56.78°N, 142.74°W		Mail		one Week			
	ε	41.7°N, 63.53°E		Tape		Four Weeks			

† Leave Capability for Movable Platform and Possibly an Altitude.

NOTE: The mode of dissemination should dictate how the DCS data should be formatted, i.e., mag tape, paper tape, listings, charts. In all cases, a listing should be provided for at least internal DSL use and a copy for the user unless he does not request it. This copy is not the same as this format for general DSL use.

Figure 4-5 Data Collection Subsystem Monitor Logging Form

4.2 Photographic Production Facility and Equipment Plan

The photographic processing functions of the ERTS Data Center present some rather stringent requirements for facility planning. Most of the other functions of the Data Center can be performed in ordinary standard office space areas. In this study, we have examined the overall Data Center facility requirements from two points of view: (1) Within the constraints of the space available in Building 23 at Goddard Space Flight Center, and (2) from estimated projections of the ERTS data system growth requirements. Technical Report No. 11 (Contract NAS 5-10343) discusses a plan for a photographic production facility for Building 23 (GSFC). A detailed plan is herein suggested for a flexible offsite facility, able to satisfy the growing needs of a variety of imaging sensors on unmanned satellites.

It is strongly recommended that the MPPL not be combined with the many and varied duplicating film chemistries that must be associated with the Photographic Production Laboratory. Only through isolated control of raw data can accurate and valid interpretation be guaranteed for engineering assessment of the ERTS sensors and display systems.

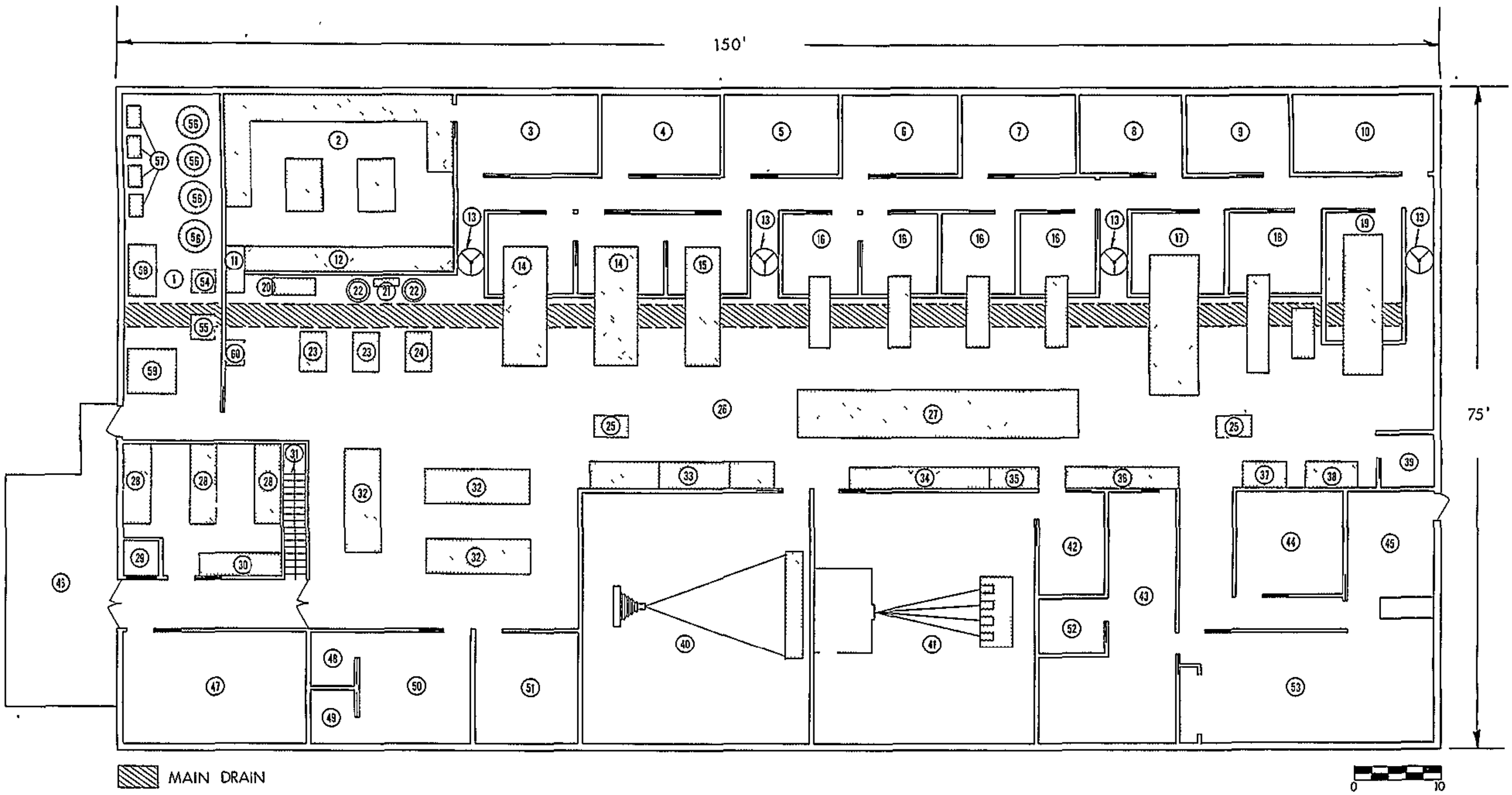
4.2.1 Optimal Plan for the Production Photographic Laboratory (PPL)

The successful design of a precision photographic laboratory begins with an understanding of the types of processing equipment that are to be used. The area layout is then planned around those equipments and their constraints, rather than vice versa.

A design plan for an offsite PPL is presented in Figure 4-6. In developing this design we have utilized our operational understanding of the types of processing equipment to be employed and the constraints that are inherent to each processor. An overlay presents the suggested layout and location for the necessary chemical area which includes space and equipment for chemical storage, mixing and chemical analysis. The equipment, chemistry (including replenishment rates) and production amounts used in establishing this plan are also discussed.

The selection of equipment type has been carefully considered. It is extremely beneficial to a processing system to utilize as many units as possible that complement each other in design and manufacture, thus invoking total system responsibility. Thus, equipment maintenance would be easier and spare parts inventory would be decreased.

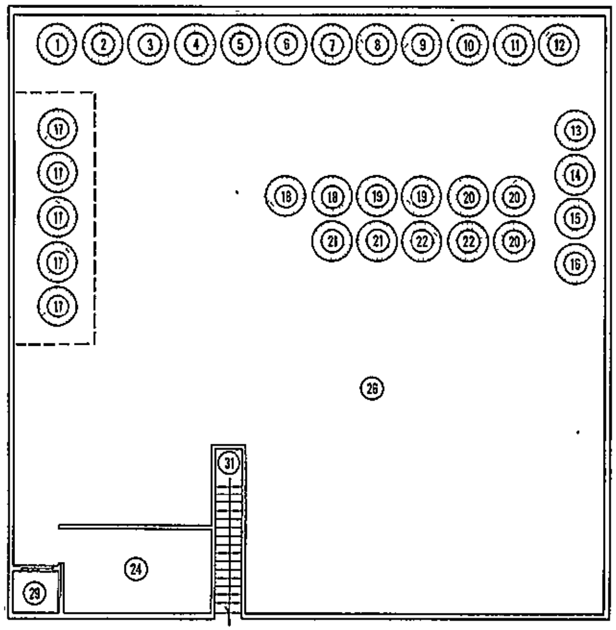
Production systems have been introduced and recommended that were not specified for ERTS photographic production. The inclusion of these systems in early



LEGEND

1 Utility Room
2 Black and White Custom and Precision Printing and Processing
3 Black and White Precision Printing (Durst V-184)
4 Niagra Continuous Strip Printing
5 Miller-Holzworth EN/46
6. Enlarging Room (Durst V-184) or 8"x10" Omega
7 SP 10/70 and Niagra
8. Mark III LogEtronic Color Printer
9 Chromega 8"x10" Enlarger
10 Color Precision Printing (Durst G-184)
11. Light Tight Sluice
12. Hand Processing Sink
13 Revolving Dark Room Door
14 Simplex 52" Black and White Paper Processor
15 Simplex 32" Black and White Paper Processor
16 Versamat Black and White Film Processor
17 Simplex 52" Wide Track Color Track Color Paper Processor
18 Versamat Model 1811 Color Film Processor
19 Simplex Tricolor Film Processor
20 Sink
21 Vertical Print Drain Board
22. Rotary Print Washer
23 Glossy Dryer
24 Matte Dryer
25 Viewing Table - 2 Strand
26 Finishing Room
27. Print Sorting Table
28. Freezer, Color-Sensitized Material
29 Elevator to Chemical Mix and Storage
30 Color Film Warm up Bench
31. Stairway to Upper Level
32 Bench Tables
33. Light Tables
34 Quality Control Instruments
35 Film Editing and Splicing Table
36 Production Control Bench
37. Production Supervisor Desk
38 Color Viewing Table
39 Color Video Analyzer
40 Montage Preparation and Copy Room
41 Color Composite Production Room
42. Slide, Vugraph Preparation and Mounting
43 Reproduction Film Library
44. Facility Office
45. Lobby
46 Receiving and Loading Platform
47 Black and White Film and Paper Storage
48. Lavatory (Men)
49 Lavatory (Women)
50 Employees Lounge, Lunch Area
51 Maintenance and Spare Parts Room
52. Sheet Film Library
53. Job Control Office
54 Chemical Regeneration System
55. Silver Reclamation System
56. Water Heaters
57 Water Chillers
58 Heating System
59. Air Conditioning System
60. Versamat Rack Washer

Figure 4-6 Proposed Floor Plan for the Photographic Processing Laboratory



LEGEND

1	250 gal Capacity Color Paper Dev Storage	
2.	" " " " " Stop	
3	" " " " " Hardner	
4	" " " " " Bleach	
5.	" " " " " Fix	
6.	" " " " " Buffer	
7.	250 gal. Capacity Color Film Dev	
8	" " " " " Neutralizer	1811
9	" " " " " Prehardner	
10.	" " " " " Hardner	
11	" " " " " Int-Neg. Dev	Tricolor
12	" " " " " C-22 Dev	
13.	" " " " " Stabilizer	
14.	" " " " " Fix	1811 and
15.	" " " " " Bleach	Tricolor
16.	" " " " " Stop	
17.	250 gal Capacity Chem Mix Tanks with Overhead Power Exhaust	
18.	250 gal. Capacity B and W Paper Dev Storage	
19.	" " " " " Stop	
20.	" " " " " Fix	
21.	" " " " Film Dev	
22.	" " " " " Fix	
24.	Chemical Analysis Laboratory	
26.	Dry Chemical Storage	
29	Elevator	
31.	Stairway	

planning should be seriously considered. Photographic information acquired from ERTS sensors will have to be provided in many and varied image formats. Production systems in laboratories always expand. The design concepts offered in this facility will provide for all these circumstances and will offer a production system that will be economically sound and versatile for future ERTS requirements.

The equipment suggested for the ERTS PPL is thought to be the best available for the listed reproduction requirements. Other nearly equivalent equipment is now available, and advancing technology will make new equipment available in the future. Therefore, a continuing review of suitable equipment should be made until the purchase decision is made.

4.2.2 Equipment Specification

4.2.2.1 70 mm Black and White Film Production

Printing

Tables 4-1 and 4-2* provide a listing of 70 mm black and white film production for various assumed coverages: the printing time requirements and the number of equipment units required. The printing unit suggested for this production is the LogEtronic SP10/70 Continuous Strip Printer. This unit, identified as No. 7 on Figure 4-6, prints from a roll of either positive or negative film onto any roll of film-base or paper-base photo-sensitive material. The printer features automatic control of the degree of dodging and exposure applied to the printing material as it passes through the printing area. This feature compensates for non-uniformity in the transparency and ensures uniform exposure from frame to frame, and within each frame, for a given printing material. Resolution of up to 200 lines per millimeter is attainable. The transport speed is variable, approximating 5 to 60 ft per minute. The average printing rate, as indicated in Table 4-1, is 40 ft per minute.

Processing

The output (see Tables 4-1 and 4-2) from the SP10/70 will be processed on Eastman Kodak black and white Versamat film processors (Item No. 16, Figure 4-6). This processor is designed for the developing of black and white sheet film in sizes ranging from 4" x 5" through, and including, 11" x 14". With the addition

*Tables 4-1 through 4-13 are grouped at the end of Section 4.2.2.6 for ease of review.

of roll-feed adapters, the unit can be used to process and dry continuous lengths of certain types of film up to 9-1/2" wide. Continuous lengths of narrower film can be run simultaneously; i.e., three strands of 70 mm. The speed of the processor is variable from 0 to 25 ft per minute depending on film type. Production rates for ERTS processing are based upon a processing speed of 10 ft per minute.

4.2.2.2 70 mm Black and White Paper Production

Printing

The 70 mm black and white printing requirements listed in Table 4-3 will be handled by the same LogEtronic SP10/70 used for black and white 70 mm film printing. This unit is Item No. 7 of Figure 4-6. Table 4-3 lists the hourly requirements for printing various amounts of ERTS area coverage.

Processing

Processing of the black and white paper prints will be done with a Simplex 52" wide-track processor. This processor will accommodate multiple strands of paper up to 50" wide, in either roll or sheet, at speeds up to 7 ft per minute. Table 4-4 shows the requirements for this equipment.

4.2.2.3 9-1/2" Black and White Film Production

Printing

Table 4-5 presents the requirements for the 9-1/2" data format for various types of ERTS coverage. The assumption is made that the initial negative will be 70 mm with projection printing to a 9" image size. The Miller Holzworth EN/46, i.e., Item No. 4 of Figure 4-6, is suggested for this printing operation. The unit is designed to produce four diameter (fixed focus) enlargements, on 9-1/2" wide roll film or paper, from 70 mm negatives. Consideration for a variable optical system should be invited from the manufacturer for minor scale changes. The printer will resolve up to 100 lines per millimeter. A production time of 8 seconds per frame is considered reasonable for this equipment.

Nine and one-half inch roll contact printing as identified in Table 4-6 would be accomplished by use of the Eastman Kodak Niagara Printer, which duplicates by continuous contact printing. From a primary roll of processed negative or positive film, the printer reproduces at high speed a secondary length of exposed film up to 1000 ft

long. The film transport handles any width from 70 mm to 9-1/2". A recent innovation by the manufacturer is a conversion kit that will provide a printing capability for paper-base material.

Processing

The processing of the film produced as listed in Tables 4-5 and 4-6 will be performed on Versamat black and white film processors. This processing will require four units for world coverage capability using a three-shift (24-hour) operation, assuming a realistic amount of 57,150 ft daily production (Table 4-7).

4.2.2.4 10" Black and White Paper Production

Printing

Table 4-8 presents the requirements for 10" black and white paper prints. A Niagara Continuous Strip Printer is recommended. It should be noted that two of these units (Item Nos. 4 and 7 of Figure 4-6) have been recommended for the facility. Both would be used primarily for the reproduction of film-base material, but with one conversion kit either machine can be utilized for paper production. The SP10/70 will also provide a paper printing backup to this system.

Processing

Processing of the 10" paper prints (Table 4-9) prepared on the Niagara printer would be accomplished on the Simplex 52" wide-track processor, Item No. 14 of Figure 4-6.

4.2.2.5 9-1/2" Color Film Production

Printing

Table 4-10 lists the multispectral color composite requirements. Production of color composites is planned using a projection system. This system is not commercially available. The system would be located at Item 41 of Figure 4-6. Various approaches to the equipment problem are now under study. Appendix C presents a projection concept evaluation. The primary approach is to project the registered images onto a focal plane which is large enough so that the operator can achieve exact registration through examination of the color fringing pattern or using fiducials superimposed by the computer. Image recovery would then be directly onto color negative roll film at 9-1/2" size. Careful planning should be made to insure room for this color projection system.

Processing

Color processing of the composites would be accomplished on an Eastman Kodak Model 1811 Roll Film Color Processor. This is Item No. 18 of Figure 4-6. This system will accommodate 9-1/2" roll negative color film and process dry-to-dry at a speed of approximately 6.4 ft per minute (Table 4-11).

4.2.2.6 10" Color Paper Production

Printing

Table 4-12 lists the color print requirements for various types of earth coverage. This printing will be performed on the LogEtronic Mark III Color Contact Printer. The printer offers scanning beam modulation that brings out full detail in the highlight, shadow and mid-tone areas on color film or paper. It accepts sheet negatives up to 10" x 10" and roll film 10" wide. It is better described as a step and repeat printer, each exposure being made by manual control, with the raw film transport being effected automatically. A 30-second printing time has been assumed for the exposure of one frame of data. Information received from the manufacturer and some users of the equipment indicates that a normal color negative can be expected to take at least 8 seconds of exposure time. This estimate, combined with estimates for placing and removal of the original stock, provides an overall estimate of printing time. It is believed that an experienced operator can eventually reduce this amount of time.

Processing

Table 4-13 presents the color paper print processing requirements. This production will be accomplished by using the Simplex 52" Wide-Track Color Paper Processor. The machine will process four strands of 10" wide roll paper simultaneously or single sheets up to 50" in width.

4.2.2.7 Auxiliary Equipment and Space Requirements

Figure 4-6 presents a number of additional pieces of equipment and floor space that are considered essential to the operation of the Photographic Production Laboratory, but are not part of the equipment listing directly related to the production listed in Tables 4-1 through 4-13.

TABLE 4-1

70 mm BLACK AND WHITE FILM PRINTING TIME AND EQUIPMENT REQUIREMENTS FOR THE LogEtronic SP 10/70

Coverage	Daily Production in Feet	Printing Time** Hours 3 Strands at 40 FPM	Equipment Units for Shift Operation 8-Hour Day	16-Hour Day	24-Hour Day
U S Only	2,100	54	1	1	1
Less Data Lost from Cloud Cover and Readout*	1,050	.396	1	1	1
Additional Hour of Taped Data 5x (Factor)	10,500	1 71	1	1	1
Less Data Lost from Cloud Cover and Readout	5,250	.98	1	1	1
World Coverage 15x (Factor)	31,500	4 6	1	1	1
Less Data Lost from Cloud Cover and Readout	15,750	2 44	1	1	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1.)

**This time includes machine setup and exposure control test

TABLE 4-2

70 mm BLACK AND WHITE FILM DEVELOPING TIME AND EQUIPMENT REQUIREMENTS FOR THE KODAK VERSAMAT 11C

Coverage	Daily Production in Feet	Processing Time** Hours 3 Strands at 10 FPM (Dry to Dry)	Equipment Units for Shift Operation 8-Hour Day	16-Hour Day	24-Hour Day
U S Only	2,100	1 7	1	1	1
Less Data Lost from Cloud Cover and Readout*	1,050	1 08	1	1	1
Additional Hour of Taped Data 5x (Factor)	10,500	6 3	1	1	1
Less Data Lost from Cloud Cover and Readout	5,250	3 4	1	1	1
World Coverage 15x (Factor)	31,500	18 0	2	1	1
Less Data Lost from Cloud Cover and Readout	15,750	9 25	2	1	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes quality control checks and processor load.

TABLE 4-3

70 mm BLACK AND WHITE PAPER PRINTING TIME AND EQUIPMENT REQUIREMENTS FOR THE LogEtronic SP 10/70

Coverage	Daily Production in Feet	Printing Time** Hours 3 Strands at 40 FPM	Equipment Units for Shift Operation 8-Hour Day	16-Hour Day	24-Hour Day
U S Only	1,035	39	1	1	1
Less Data Lost from Cloud Cover and Readout*	517 5	32	1	1	1
Additional Hour of Taped Data 5x (Factor)	5,175	97	1	1	1
Less Data Lost from Cloud Cover and Readout	2,587 5	61	1	1	1
World Coverage 15x (Factor)	15,525	2 40	1	1	1
Less Data Lost from Cloud Cover and Readout	7,762 5	1 08	1	1	1

*Approximately 50% of data is expected to be lost to cloud contamination and data loss during satellite-ground data command and readout (See Ref 1)

**This time includes machine setup and exposure control test.

TABLE 4-4

70 mm BLACK AND WHITE PAPER DEVELOPING TIME AND EQUIPMENT REQUIREMENTS FOR THE SIMPLEX 52" WIDE TRACK PROCESSOR

Coverage	Daily Production in Feet	Processing Time** Hours 8 Strands at 5 FPM (Dry to Dry)	Equipment Units for Shift Operation 8-Hour Day	16-Hour Day	24-Hour Day
U S Only	1,035	.93	1	1	1
Less Data Lost from Cloud Cover and Readout*	517 5	715	1	1	1
Additional Hour of Taped Data 5x (Factor)	5,175	2 66	1	1	1
Less Data Lost from Cloud Cover and Readout	2,587 5	1.58	1	1	1
World Coverage 15x (Factor)	15,525	6 97	2	1	1
Less Data Lost from Cloud Cover and Readout	7,762 5	3 735	1	1	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes quality control checks and processor load

TABLE 4-5

9-1/2" BLACK AND WHITE FILM PRINTING TIME AND EQUIPMENT REQUIREMENTS FOR THE EN/46 MILLER-HOLZWORTH†

Coverage	Frames	Printing Time** Hours 1 Strand at 8 Sec per Frame	Equipment Units for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U S Only	231	75	1	1	1
Less Data Lost from Cloud Cover and Readout*	115	50	1	1	1
Additional Hour of Taped Data 5x (Factor)	1,155	2 88	1	1	1
Less Data Lost from Cloud Cover and Readout	577	1.50	1	1	1
World Coverage 15x (Factor)	3,465	7 95	1	1	1
Less Data Lost from Cloud Cover and Readout	1,732	4 10	1	1	1

*Approximately 50% of data is expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes machine setup and exposure control test

†70 mm negative magnified to a 9" x 9" positive image format utilizing step-and-repeat exposure method

TABLE 4-6

9-1/2" BLACK AND WHITE FILM PRINTING TIME AND EQUIPMENT REQUIREMENTS FOR THE EASTMAN KODAK NIAGARA PRINTER†

Coverage	Daily Production in Feet	Printing Time** Hours 1 Strand at Approx. 100 FPM	Equipment Units for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U S Only	7,389	1 48	1	1	1
Less Data Lost from Cloud Cover and Readout*	3,694 5	87	1	1	1
Additional Hour of Taped Data 5x (Factor)	36,945	6 41	1	1	1
Less Data Lost from Cloud Cover and Readout	18,472 5	3 33	1	1	1
World Coverage 15x (Factor)	110,835	18 72	3	2	1
Less Data Lost from Cloud Cover and Readout	55,417 5	9.49	2	1	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref. 1)

**This time includes machine setup and exposure control test

†Printing operation provides for both positive and negative production on a continuous strip printer.

TABLE 4-7

9-1/2" BLACK AND WHITE FILM DEVELOPING TIME AND EQUIPMENT REQUIREMENTS FOR THE VERSAMAT PROCESSOR 11C

Coverage	Daily Production in Feet	Processing Time** Hours 1 Strand at 10 FPM (Dry to Dry)	Equipment Units for Shift Operation		
			8-hour Day	16-Hour Day	24-Hour Day
U S Only	7,620	13 20	2	1	1
Less Data Lost from Cloud Cover and,Readout*	3,810	6 85	1	1	1
Additional Hour of Taped Data 5x (Factor)	38,100	64.0	8	4	3
Less Data Lost from Cloud Cover and Readout	19,050	32 25	5	3	2
World Coverage 15x (Factor)	114,300	191 0	24	12	8
Less Data Lost from Cloud Cover and Readout	57,150	95 75	12	6	4

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout (See Ref. 1)

**This time includes quality control checks and processor load

TABLE 4-8

10" BLACK AND WHITE PAPER PRINTING TIME AND EQUIPMENT REQUIREMENTS FOR THE EASTMAN KODAK NIAGARA PRINTER

Coverage	Daily Production in Feet	Printing Time** Hours 1 Strand at 100 FPM	Equipment Units for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U S Only	3,810	.88	1	1	1
Less Data Lost from Cloud Cover and Readout*	1,905	.57	1	1	1
Additional Hour of Taped Data 5x (Factor)	19,050	3.42	1	1	1
Less Data Lost from Cloud Cover and Readout	9,525	1.84	1	1	1
World Coverage 15x (Factor)	57,150	9 77	2	1	1
Less Data Lost from Cloud Cover and Readout	28,575	5 02	1	1	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes machine setup and exposure control test

TABLE 4-9

10" BLACK AND WHITE PAPER DEVELOPING TIME AND EQUIPMENT REQUIREMENTS FOR THE SIMPLEX 52" WIDE TRACK PROCESSOR

Coverage	Daily Production in Feet	Processing Time** Hours 4 Strands at 5 FPM (Dry to Dry)	Equipment for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U S Only	3,810	3 67	1	1	1
Less Data Lost from Cloud Cover and Readout*	1,905	2 08	1	1	1
Additional Hour of Taped Data 5x (Factor)	19,050	16 37	3	2	1
Less Data Lost from Cloud Cover and Readout	9,525	8 44	2	1	1
World Coverage 15x (Factor)	57,150	48 12	7	4	3
Less Data Lost from Cloud Cover and Readout	28,575	24 31	4	2	2

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes quality control checks and processor load

TABLE 4-10

9-1/2" COLOR FILM MULTISPECTRAL COMPOSING TIME AND EQUIPMENT REQUIREMENTS (TO BE DEVELOPED)

Coverage	Daily Production in Feet	Composing Time** Hours at 5 min. per Frame	Equipment for for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U. S Only	22	2 0	1	1	1
Less Data Lost from Cloud Cover and Readout*	11	1 09	1	1	1
Additional Hour of Taped Data 5x (Factor)	110	9 34	2	1	1
Less Data Lost from Cloud Cover and Readout	55	4 75	1	1	1
World Coverage 15x (Factor)	330	27 67	4	2	2
Less Data Lost from Cloud Cover and Readout	165	13 92	2	1	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**Includes time for initial setup, registration, and color balance

TABLE 4-11

9-1/2" COLOR FILM (NEGATIVE ONLY) DEVELOPMENT TIME AND EQUIPMENT REQUIREMENTS FOR THE EASTMAN KODAK MODEL 1811 ROLL FILM COLOR PROCESSOR

Coverage	Daily Production in Feet	Processing Time** Hours 1 Strand at 6 4 FPM (Dry to Dry)	Equipment Units for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U S Only	99	1 0	1	1	1
Less Data Lost from Cloud Cover and Readout*	49 5	1 0	1	1	1
Additional Hour of Taped Data 5x (Factor)	495	1 7	1	1	1
Less Data Lost from Cloud Cover and Readout	247 5	1 14	1	1	1
World Coverage 15x (Factor)	1,485	4 36	1	1	1
Less Data Lost from Cloud Cover and Readout	742 5	2 43	1	1	1

* Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes machine setup and exposure control test.

TABLE 4-12

10" COLOR PAPER PRINTING TIME AND EQUIPMENT REQUIREMENTS (STEP AND REPEAT) FOR LogEtronic MARK III COLOR PRINTER

Coverage	Daily Production Frames	Printing Time* Hours 1 Strand at 30 Sec per Frame	Equipment Units for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U S Only	435	4 12	1	1	1
Less Data Lost from Cloud Cover and Readout*	218	2 3	1	1	1
Additional Hour of Taped Data 5x (Factor)	2,175	18 6	3	2	1
Less Data Lost from Cloud Cover and Readout	1,088	9 5	2	1	1
World Coverage 15x (Factor)	6,525	54 87	7	4	3
Less Data Lost from Cloud Cover and Readout	3,263	27.6	3	2	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes machine setup and exposure control test.

TABLE 4-13

10" COLOR PAPER DEVELOPING TIME AND EQUIPMENT REQUIREMENTS FOR THE SIMPLEX 52" WIDE TRACK PROCESSOR

Coverage	Daily Production in Feet	Processing Time** Hours 4 Strands at 2 5 FPM (Dry to Dry)	Equipment Units for Shift Operation		
			8-Hour Day	16-Hour Day	24-Hour Day
U S Only	435	1 22	1	1	1
Less Data Lost from Cloud Cover and Readout*	217 5	.86	1	1	1
Additional Hour and Readout 5x (Factor)	2,175	4 12	1	1	1
Less Data Lost from Cloud Cover and Readout	1,087 5	2 31	1	1	1
World Coverage 15x (Factor)	6,525	11.37	2	1	1
Less Data Lost from Cloud Cover and Readout	3,262 5	5 94	1	1	1

*Approximately 50% of data was expected to be lost to cloud contamination and data loss during satellite-ground data command and readout. (See Ref 1)

**This time includes quality control checks and processor load

Utility Room

Item No. 1 of Figure 4-6: All units described in this room will provide the necessary environmental atmosphere, hot and cold water service, chemical regeneration and silver reclamation systems.

Black and White Custom Precision Printing and Processing Room

Although the ERTS photographic requirements do not specifically describe custom printing and processing, it would be inconceivable to plan a photographic support facility without appropriate laboratory equipment to provide these services. Item No. 2 identifies the location of a custom room on Figure 4-6. The equipment will not be utilized for major production, but will be used for the frequent and unique reductions or magnifications, special overlays, grids and other special processing requests. Equipment needed to support this operation would be a 70 mm black and white enlarger, a 4" x 5" black and white enlarger, a contact printer, and a sink large enough to provide for adequate hand-processing in trays. Enjoined with this equipment is other finishing room equipment, such as print washers (22), print drainboard (21), and print dryers (23) and (24).

Special Printing (Black and White)

This room (Item No. 3 of Figure 4-6) would contain a Durst V-184 Enlarger and Easel with pin-registered negative carriers and pin-registered vacuum board. The enlarger will accept 9" x 9" roll film negatives with film advance release and rewinds. Material to be processed would be passed through a wall opening into Room No. 2. Another unit identified as the Kargl Auto-Focusing Rectifier Enlarger can be considered for this production. This system will accommodate 9-1/2" roll film and is designed to eliminate image displacement. Change in scale is accomplished at the same time as angle rectification.

8" x 10" Enlarger - Durst V-184 or Omega

This enlarger, located at Item No. 6 of Figure 4-6, would be utilized to provide support for data requests from other than the routine users or experimenters. In the Nimbus operation, data that displays a unique pictorial scene or unusual phenomena are frequently used for PIO releases and may even take precedence over scheduled work flow. This demand for large quantity production must be met; e.g., NASA Headquarters has also requested this support on Nimbus and ATS data. Interruptions of work flow to provide this support can and will cause costly delays in the delivery of routine production. A Simplex 32"

black and white processor (No. 15) complements this printer and would be used to provide a separate processing capability. It is, therefore, strongly recommended that a supplemental system of this type be considered for the facility.

Chromega 8" x 10" Enlarger

This unit, Item No. 9 of Figure 4-6, would be used to provide a high-volume color print production for the other than routine precision color production. Exposures would be effected to a roll paper transport easel allowing mass production of color prints up to 16" wide. Processing would be effected on the Simplex 52" wide-track color paper processor (No. 17) without affecting routine production.

Durst G-184 Color Enlarger

This unit (Item No. 10, Figure 4-6) will provide for the precision enlarging. Registration to be effected to a pin-registered vacuum easel. The negative carrier ensemble also has pin-registration equipment. The enlarger will accept 9-1/2" x 9-1/2" negatives and will be used to produce enlargements on sheet color films and papers. It is believed that additional requests will be received for color internegatives, positive color transparencies, color vugraphs and color slides. The Simplex tricolor processor, Item No. 19, will provide for this precision processing, and the other color film production requests, without an additional chemistry system.

4.2.2.8 Additional Miscellaneous Facilities and Equipment

The following lists, for identification, various equipment and floor space requirements outlined on Figure 4-6. They will be listed by their identifier number on Figure 4-6. Some items may have brief discussion, others are thought to be self-explanatory.

Item No.	Item	Comments
11	Light Tight Sluice	-
12	Hand Processing Sink	-
13	Light Lock	-
20	Sinks	For washing and cleaning of equipment components in the automatic processors.
21	Vertical Print Drainboard	For use as a location to squeegee prints before introduction into dryers.
22	Rotary Print Washer	To provide a wash capability for all sheet paper.
23	Glossy Dryer (26")	Provides a glossy dry capability for all black and white (B&W) sheet paper.
24	Matte Dryer	Provides a matte dry capability for black and white paper.
25	Film Viewing Table	Provides simultaneous scene inspection of two processed film rolls. Both strands, moving in either direction, can be synchronized to hold close frame-by-frame registration for parallel comparison.
26	Finishing Room	The design concept offered in this facility will allow for two persons to monitor the processing machinery in this room. It should be noted that all machinery, instruments, and controls will be visible and accessible to anyone in the finishing area.
27	Print Sorting Table	-
28	Freezer, Color-Sensitized Material	Three freezer units are shown in this storage area. Each unit having a storage capacity of 100 cu. ft., allowing for approximately three weeks of material storage. It is suggested that the film supplier maintain bulk storage for at least 60 days' operation in the area with a scheduled delivery cycle to keep this stock replenished.

Item No.	Item	Comments
29	Elevator to Chemical Mix and Storage	-
30	Color Film Warmup Bench	-
31	Stairway	-
32	Bench Tables	-
33	Light Viewing Tables	-
34	Quality Control Instruments	-
35	Film Splicing and Editing Table	The editing table is used to inspect, edit and assemble processed roll film in widths from 70 mm to 9-1/2". It is also used to splice on special leader and identifying material.
36	Production Control Bench	-
37	Production Supervisor's Desk	-
38	Color View Table (Avlites or Macbeth)	-
39	Color Video Analyzer	This unit provides a means of evaluating the image on color negative film. It electronically scans, reverses, and displays a positive full-color image of the negative on a video tube. The operator can adjust the visual brightness and color balance of the image. The numerical values of the control settings can be fed into a negative translator at the printing equipment. The translator is, in effect, a computer that integrates the characteristics of the color printer or enlarger, the print material, the print process and the color negative, to provide the correct filter settings and exposure time.

Item No.	Item	Comments
40	Montage Preparation and Copy Room	Depending upon montaging volume and size, a copy camera, with vacuum frame and necessary lighting, will have to be provided. A camera providing imagery up to 20" x 20" should prove adequate.
41	Color Composite Room	-
42	Slides, Vugraph Preparation and Mounting Room	Although ERTS requirements do not specify this production, they will undoubtedly become necessary. A separate room has been advanced in the design concept to facilitate the mounting equipment needed to perform this ultimate task.
43	Reproduction Film Library	This will contain open shelving for the storage of all roll film negative containers.
44	Office	-
45	Lobby	-
46	Receiving and Loading Platform	-
47	Black and White Film and Paper Storage	-
48	Lavatory - Men	-
49	Lavatory - Women	-
50	Employees Lounge	-
51	Maintenance and Spare Parts Room	-
52	Sheet Film Library	It is suggested that a motor shelf file be installed in this space. A commercial type identified as the Acme Visible Astromatic, 96" high, will provide fourteen 5-ft cradles. All sheet negatives from 70 mm up to 10" x 10" would be filed in this system.

Item No.	Item	Comments
53	Job Control	-
54	Chemical Regeneration	-
55	Silver Reclamation	-
56	Water Heaters	-
57	Water Chillers	-
58	Heating System	-
59	Air Conditioning	-
60	Versamat Rack Cleaner	-

4.2.3 Maintenance

Preventive maintenance is the most important aspect of operating a production laboratory.

Automatic processing equipment requires constant monitoring for wear in the many small, yet important parts of a processing system. The replacement of these parts must be made before breakdown. A spare parts inventory must be held and updated on a continuing cycle. Necessary tools to provide a good maintenance program must be acquired and stored properly..

An area approximating 8 ft x 8 ft would contain the required parts and tools necessary to support equipment to this facility.

4.2.4 Chemical Storage, Mixing and Replenishment

There is an obvious need to store and mix many types and amounts of chemical solutions to support the operation. These operations often use powdered chemicals which are not compatible with a clean processing area. We recommend that a separate mixing and storage area be provided above the photographic processing areas. This design concept will provide a gravity feed system to all processing machinery. Attempts to install a pumping replenishment system (in lieu of gravity feed) have not been entirely successful in the NADUC operation. The operating cost and production interruptions due to pump problems, etc., were far greater than the extra cost required to install a two-level gravity system.

Accordingly, it is recommended that 1250 sq. ft. of space be planned for a chemical mix and storage area located directly above the processing laboratory. This area would require air-conditioning to maintain a cool and dry environment. The overlay shown in Figure 4-6 describes a suggested chemical mixing and storage area. It will contain a chemical analysis station where statistical data can be compiled which will provide facts in chemistry deviation so that the necessary preventive measures can be taken before solutions are introduced to the processing cycle.

The approximate chemical replenishment rates and storage requirements that can be anticipated for the major processing equipment are detailed below.

4.2.4.1 Versamat Black and White Film Processing, Solution and Storage

Approximately 200 cc per minute of developer and 300 cc of fix solution will be introduced to the processor while running at speeds approximating 10 frames per minute. Two 250-gallon storage tanks of developer and two 250-gallon storage tanks of fix will provide a one-day storage capacity.

4.2.4.2 Simplex Black and White Paper Chemistry Storage

Approximately 30 cc of developer, 30 cc of stop and 45 cc of fix per sq. ft. of paper processed will be expended in this system. Two storage tanks with a 250-gallon capacity for fix will supply two days of replenishment for this processing system.

4.2.4.3 Versamat 1811 and Simplex Tricolor Film Chemistry and Storage

Developer replenishment of approximately 200 cc per sq. ft. of material processed will be delivered to these systems. Six additional color-processing chemicals will each replenish at approximately 90 cc per sq. ft. Four of these chemicals will also provide for the tricolor system with three additional chemical solutions needed. The combined systems will require ten 250-gallon capacity storage tanks to sustain one week of operation.

4.2.4.4 Simplex Color Paper Chemistry and Storage

Replenishment from six chemical solutions will be delivered at the system at approximately 69 cc per sq. ft. of material processed. Six 250-gallon storage tanks will provide for one week of operation.

4.2.5 Environmental Requirements

Critical photographic processing activities cannot tolerate dusty or dirty environments. The ERTS imagery presents resolution elements approximately 25 μm in size on 70 mm formats. Dust particles often exceed 25 μm. Consultation with environmental control engineers is required to insure proper design of a ventilation and air-conditioning system.

Facility planning should also emphasize accessibility under sinks, benches and processing equipment for cleaning. Air-conditioning units should be provided with accessible filters both at intakes and outlets. Periodic filter changing and cleaning should be a regular part of the photographic laboratory maintenance. The proper interior construction finish will greatly reduce dust accumulation; i.e., floors with vinyl or epoxy finish carried up to 4 ft from wall base. Ceilings should be epoxy or polyester coating or with plastic-finish acoustical tiles.

4.2.6 Water and Electrical Requirements

The size of the main supply or intake pipe depends on the total amount of water to be used in the installation. A general estimate of water usage can be obtained if a consumption rate of 5 gallons per minute (gpm) is applied to each black and white processing machine and 7 gpm to each color-processing machine. The proposed facility design introduces seven black and white machines and three color-processing machines, for a total rate of 56 gpm. Additional usage will be obtained from other manual processing equipment, such as washers, sinks, etc. An estimated gpm flow rate to sustain the complete facility would approximate 75 gpm. A water pressure delivery rate of at least 35 psi should be obtained at each major piece of automatic processing equipment.

Photographic solution temperatures should be adjustable from 60 to 110°F $\pm$ 1° and are, therefore, dependent on reliable hot and cold water supply. A cold water supply should be at least 10°F below operating temperature, and a hot water supply 30°F above operating temperature with the defined delivery rates. A water supply filtering system should be installed on the main input to remove 50 µm or larger particles. Additional filtration for smaller particles 1 µm or larger must be introduced at the service lines adjacent to processing equipment.

Electrical service to the laboratory is dependent upon types and amounts of equipment. The automatic processors, dryers and printing equipment operate on a number of standard electrical services including 208 and 220 volts (single and three-phase) and 110 volts. Amperage loads would be commensurate with equipment requirements.

Voltage fluctuations on printing and enlarger lamps cannot be tolerated and a constant voltage must be provided. (Changes in voltage of electric current are followed by corresponding changes in color temperature of tungsten lamps. This, in turn, alters the color balance of color transparencies and prints.)

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4.2.7 Silver Reclamation

In recent years, considerable attention has been given to the conservation of silver. Photographic films, plates, and papers release silver during fixation as do some stop or neutralizing solutions. Many and varied systems have been designed to recover this silver. Generally, these systems are units attached or adjacent to a processing machine. Consideration should be given to the possible collection of all discharged solutions to one location to confine the silver recovery to a single unit. Additionally, a recycle operation could return 50% of regenerated fix solution for further use.

4.2.8 Waste Disposal

The plan offers a straight-line, open-pit main drain with cover (Figure 4-7), running the longitudinal length of the laboratory. This will permit fewer plumbing junctions and allow for easier installation or removal of equipment. The circled insert describes a floor pitch extending 8 ft out from each side of the drain. The drain will also accommodate additional service lines; i.e., silver reclamation and chemical regeneration. These effluents can then be fed to a central processing station for recovery. Additionally, the drain will afford a safety factor for any processing equipment that may overflow or develop leaks and allow for easier washdown and flushing of equipment when necessary.

The nature of photographic processing wastes requires that the drainage line be constructed of acid-resistant and corrosion-resistant materials. In addition, the line should be able to withstand rapid fluid temperature changes without cracking. Many laboratory drain systems made with materials technically considered unsuitable have been used successfully over a period of years. A wide margin of safety is ensured, however, by choosing a material that is resistant to full-strength processing solutions.

One recommended material is stainless steel. Although expensive, 18-8 Molybdenum Stainless Steel, AISI Type 316, is excellent for waste lines because of its greater resistance to corrosion as compared with ordinary stainless steel Type 304. Cast iron is the most commonly used material for waste pipes and fittings, although it will eventually rust in the presence of corrosive solutions. Various plastics, such as polyethylene, polyvinyl and polyester Fiberglas can be fabricated into drain pipes of all sizes.

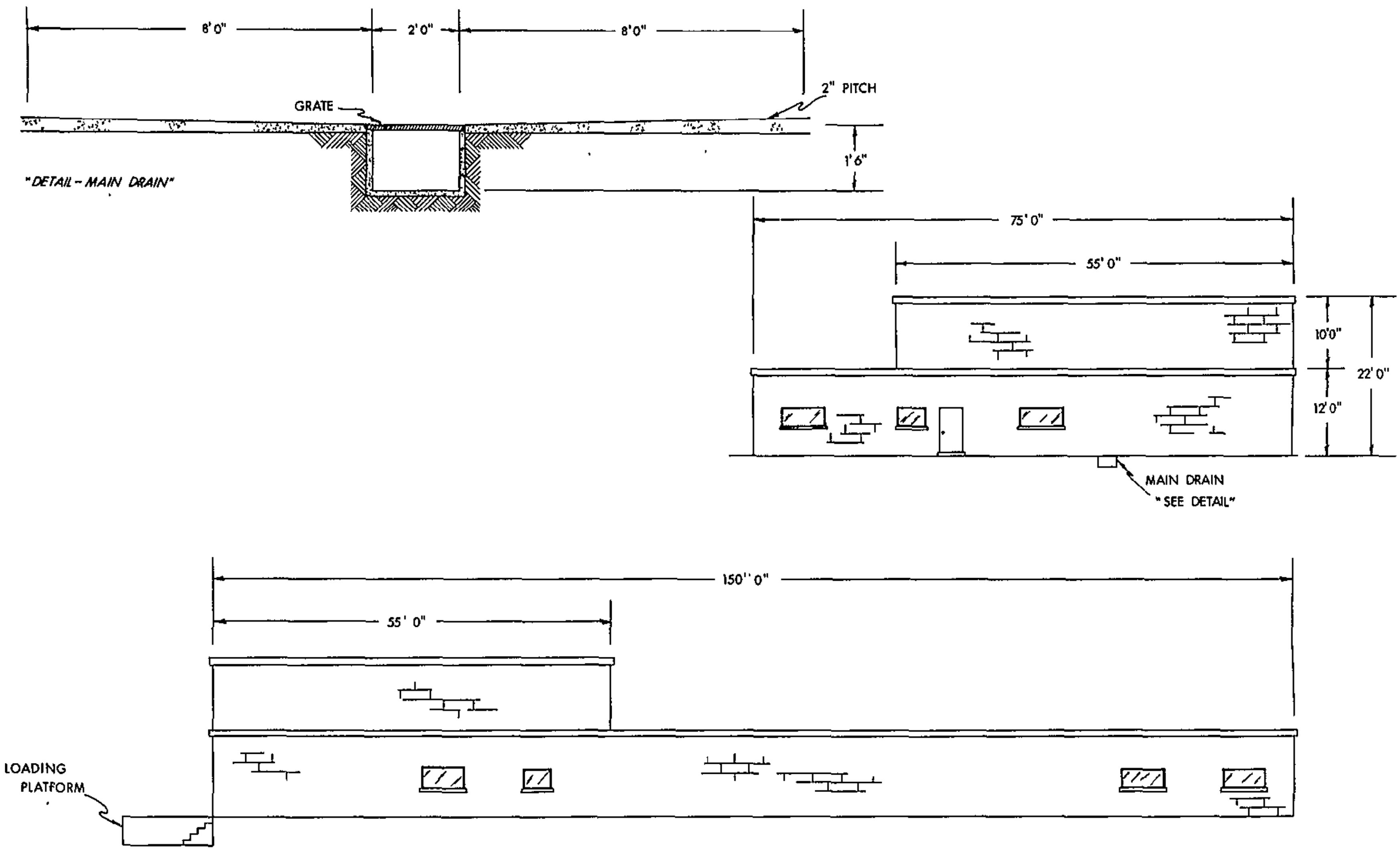

Figure 4-7 Elevation Plan of Proposed Photographic Processing Laboratory (PPL) Showing Detail of Main Drain

Large-scale processing machines operate on a continuously replenished system, not in batches. During normal operation there is no dumping of solutions. However, because of emergency and periodic maintenance shutdown or the exhaustion of solutions, occasional dumping of a solution may be necessary. If this is done suddenly, it may overload a waste-treatment plant. A sudden dumping may allow some of the chemicals to pass through a treatment plant, polluting the water into which the effluent flows.

The concentration of chemistry found in photographic processing effluents is dependent on processing practices followed in the laboratory, etc. The water consumption may be 50% to 90% of the total volume of chemicals flowing into drain and disposal systems. These wastes generally contain less than .005% of processing chemistry with machine wash water discharge or overflow. Other water discharge from sinks, sanitary facilities, etc., will provide additional dilution before it leaves the processing plant.

It is believed that a 100 gallon dilution or holding tank in an area adjacent to the PPL will provide adequate dilution for any emergency dump into the building waste lines.

4.2.9 Sensitized Material Storage

Color

Color films and papers are perishable products which are damaged by high temperature and high relative humidities.

When films are intended for critical use, requiring uniform results, they should be stored at 0° to 10°F in a freezing unit. This type of storage will arrest changes in film characteristics.

Film material removed from such storage should be allowed to reach approximate room temperature before they are opened, otherwise moisture from outside the package may condense on the film surfaces. A safe rule of thumb is: the film should be in the processing environment for at least eight hours before introduction of an exposure cycle. A storage area for color materials should provide 0° to 10°F at approximately 50% relative humidity.

Black and White

Black and white sensitized material storage requirements are not as critical as those required by color material. A storage area with a temperature control capability to 40°F and relative humidity to 40% will provide ideal storage conditions for materials to be used within one year.

4.2.10 Processed Film Storage and Retrieval

Processed films will last for many years when handled and stored under proper conditions. Color films do contain dyes that will deteriorate to some extent. For the best storage they should be stored away from bright light. The recommended storage environment that will provide optimum image quality is a temperature of 60°F, and a relative humidity of 30 to 40%.

A film library is recommended for the ERTS facility. It should be designed as part of the Photographic Laboratory where the environment for storage of the color and black and white archival and working material can be easily maintained.

4.2.10.1 Storage Formats

Due to the large amounts of film products to be handled by the photographic data system on both a routine and special-request basis (see Table 3-3), the film storage and retrieval must operate in an efficient manner. In order that any such system be responsive to the external requests and internal logistics, the nature of the requests and logistics must be examined. As the number of orbits increases it would appear efficient from an internal storage volume and logistics viewpoint to combine the orbital packages into a coherent grouping. The coherency of the grouping is in part dependent on an estimate of the format in which user requests will arrive.

Experience with the Nimbus and ATS data center has indicated that the requests are largely made on the basis of geographic location and time. The ERTS will have exact orbit-keeping capabilities and the geographic location and time will be highly correlated. We, therefore, suggest that the archival masters and the working masters be arranged for storage according to geographic zone. A manual retrieval system can be established which will be suitable for mechanical automation in the future. The following suggested zone storage system is designed to meet these requirements.

The Continental United States is divided into 12 zones with 5° longitude intervals as shown in Figure A-2. During one complete U. S. coverage period (18 days), three or four orbits of RBV and MSS data will be obtained for each zone. The working master RBV data and the working master MSS data are separately accumulated on reels for each zone. The three channels of RBV per orbit and the four channels of MSS will be sequentially spliced (in the same repetitive manner for each orbit of data) on each reel. Additional RBV and MSS orbital coverages for each zone will be added to each reel until the reel is full. New reels will be built up for each zone in a similar manner.

All orbit identification labels should be affixed to the archival negative for automatic reproduction on all future film generations. These labels, affixed at the beginning of each spectral channel of data, will identify the system (RBV or MSS), spectral channel, data, orbit and zone number. Frame identification information will be automatically added to the archival film by the ground station equipment.

The RBV and MSS archival data from each orbit of an 18-day coverage period should be temporarily stored on separate 100-ft reels. At the end of each coverage period all RBV and MSS data should be spliced onto two 500 ft reels by consecutive east-to-west longitude coverages. Thus, the data would be organized by consecutive zones, but each zone's coverage would not be accumulated on a separate reel as with the RBV and MSS working masters. Subsequent 18-day coverage units will be added to the previous data or to new 500-ft reels.

4.2.10.2 70 mm and 9-1/2" Working Master Format

All imagery will be organized by zones and stored on reels. The 70 mm film will be stored on 500 ft reels and the 9-1/2" film on 250 ft reels.

The three channels of RBV (or the four from the MSS) for each data orbit should always be stored on the same reel. Although each reel will not be completely full, this procedure will allow for easier film location and retrieval.

4.2.10.3 Color Composite Negatives and Prints

Composite negatives will be produced on 10" sheet stock from the 70 mm master positive film file. One negative film copy and one positive print copy of all composites will be stored by zones in a motor shelf file.* Each negative and print will be labeled by date, orbit, time, zone, and exposure method.

4.2.10.4 Special Processed Negatives and Prints

Special processed imagery will generally be exposed on 10" negative film stock. One negative and one print of these products will be stored by zone in a motor shelf file. Each negative will be labeled by date, orbit, time, zone, and method of exposure.

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*A motor shelf file moves a preselected shelf to a position at desk level.

4.2.10.5 Montage Negatives and Prints

Montage display negatives should be reduced to catalog display presentation size. Each negative will be exposed on 20" x 20" sheet stock. Each U. S. zone display should be labeled by coverage period and zone. Each complete U. S. montage negative should be labeled by coverage period, sensor system (RBV or MSS) and spectral band.

4.2.10.6 Special and Miscellaneous Negatives and Prints

Special displays, variously formatted, will be prepared to demonstrate applications of the ERTS data. Normally the storage format will be 10" x 10" negatives and labeled with a retrieval number and stored in the motor shelf file. A master list of display titles (data applications) vs. retrieval numbers should be sufficient for quick negative retrieval.

4.2.11 Archival and Working Master Storage Requirements

The following types of film will be stored in the ERTS Photographic Laboratory:

1) Reel Film (one copy each)
   a) 70 mm archival negative
   b) 70 mm master positive
   c) 70 mm master negative
   d) 9-1/2" master positive
   e) 9-1/2" master negative

2) Sheet Stock
   a) 10" color composite negatives and prints
   b) Precision processed negatives and prints
   c) Montage negatives and prints
   d) Special display (PIO) negatives
   e) Miscellaneous sheet stock

The right-hand columns of Tables 4-14 and 4-15 present the amounts of film to be stored over a period of one year, assuming U. S. coverage.

TABLE 4-14

REEL REQUIREMENTS FOR ONE YEAR'S U S ERTS IMAGERY*

Film	Reel Size	Number of Reels
70 mm RBV Archival Negative	500 ft	30
70 mm MSS Archival Negative	500 ft	40
		70 500-ft reels
70 mm RBV Working Negative	500 ft	36
70 mm RBV Working Positive	500 ft	36
70 mm MSS Working Negative	500 ft	45
70 mm MSS Working Positive	500 ft	45
		162 500-ft reels
9-1/2" RBV Working Negative	250 ft	171
9-1/2" RBV Working Positive	250 ft	171
9-1/2" MSS Working Negative	250 ft	235
9-1/2" MSS Working Positive	250 ft	235
		812 250-ft reels

TABLE 4-15

SHEET STOCK REQUIREMENTS FOR ONE YEAR'S U. S. ERTS IMAGERY

Sheet Stock Type	System	Number of Copies per Year
Color Composites (10" x 10" sheet stock)	RBV	2300 negatives 2300 prints
	MSS	2300 negatives 2300 prints
Precision Processed Imagery (10" x 10' sheet stock)	RBV	1150 negatives 1150 prints
	MSS	1150 negatives 1150 prints
Special Displays (PIO) (10" x 10" sheet stock)	RBV or MSS	300 negatives
Copy Layouts and Miscellaneous Negatives (10" x 10" sheet stock)	Various	300 negatives
U S. Montages (20" x 20" sheet stock)	U S Zone Displays	240 negatives
	Complete U. S. Display	40 negatives

*Section 3.4 lists the assumptions and calculations for these reel requirements.

4.2.12 Film Storage Systems

4.2.12.1 Reel Film

Various cabinet and bin storage systems were evaluated for the storage of reel film. The most satisfactory was the Vidmar* storage system. Its advantages for ERTS film storage are:

1) Ideal drawer dimensions for 9-1/2" and 70 mm film
2) Drawers can be subdivided for individual reel storage
3) Drawers glide on ball bearings, can hold 300 to 400 lbs per drawer, and can be fully opened for easy access to film in the rear.
4) The top drawer of the largest model (340) is at eye-level for easy access.
5) Cabinets can be stacked on top of each other, if required, for additional storage.

Table 4-16 tabulates reel parameters of size, reel-plus-can dimensions, weight, and number of reels which will be accumulated per year for each film type.

Cabinet and Wall Space Requirements

Table 4-17 indicates that 13 cabinets (30" across, 28" deep, 59" high) can store one year's supply of 70 mm archival film, 70 mm working masters and 9-1/2" working masters. This would require 33 ft of wall space.

TABLE 4-16

REEL PARAMETERS AND STORAGE REQUIREMENTS

Film Type	Reel Parameters				
	Size	Diameter	Height	Full Reel Weight	Reels/Year
70 mm Archival	500 ft	8"	3.125"	5.75 lbs	70
70 mm Working Masters	500 ft	8"	3.125"	5.75 lbs	162
9-1/2" Working Masters	250 ft	6.125"	10"	8.50 lbs	812

*Vidmar, 11 Grammes Road, Allentown, Pennsylvania; telephone: (215) 797-9200.

4.2.12.2 Sheet Film

A motor shelf file appears to be most satisfactory to accommodate the various 10" x 10" sheet stocks. A commercial type identified as the Acme Visible Astromatic motor shelf file meets the needs. Its prime advantage for sheet stock is the ease of storage and retrieval since each cradle can be moved to the operator and exposed for easy access.

Fifty-two feet of shelf space is required to store one year's 10" x 10" sheet stock. Table 4-18 lists the footage requirements for the various types of sheet stock.

Cabinet and Wall Space Requirements

One Acme Visible Astromatic motor shelf file with fourteen 5-foot cradles will easily store the 52 feet of sheet stock. A wall space 5-1/2 feet wide, 8 feet high and 40" deep will accommodate this unit.

4.2.12.3 Montage Storage

All montages can be easily stored in one flat map-type storage cabinet.

4.2.12.4 Film Retrieval

Reel Film

Manual retrieval is the most efficient and least expensive way to move reel film from storage to the reproduction equipment. The location of a specific frame within a reel, once the reel is on the reproduction equipment, can be performed manually with fair efficiency and is the suggested procedure.

Sheet Stock

Sheet stock film will be retrieved from the motor shelf file by the operator and routed to the appropriate reproduction equipment.

4.3 User Service Activities

The ERTS data system must be responsive to an expanding number of users and user requests for data and services.

TABLE 4-17

MINIMUM VIDMAR STORAGE CABINET REQUIREMENTS FOR ONE YEAR OF FILM FROM ERTS (U. S. Coverage Only)

Vidmar cabinet specifications for one year's U. S. coverage of 70 mm archival and working master and 9-1/2" working master film.

(All drawers have 25.2" x 25.2" inside dimensions)

Cabinet space for:

70 500 ft reels of 70 mm archival negative film

162 500 ft reels of 70 mm positive and negative working master film

812 250 ft reels of 9-1/2" positive and negative working master film

Use model 340 cabinet (30" across, 28" deep, 59" high)

Each cabinet would have:

4 10.125" high drawers

2 3.75" high drawers

Each cabinet would hold:

16 250 ft reels of 9-1/2" film (in the 10.125" drawers) and

18 500 ft reels of 70 mm film (in the 3.75" drawers)

Requirement:

13 Model 340 cabinets would hold 234 70-mm reels and 832 9-1/2" reels

TABLE 4-18

STORAGE REQUIREMENTS FOR SHEET STOCK

Sheet Stock Type	Number of Folders	Shelf Storage Space (10 folders/1.5")
Color Composites	2300	29 ft
Precision Processed	1150	15 ft
Special Displays	300	4 ft
Miscellaneous negatives and copy layouts	300	4 ft
	TOTAL:	52 ft

The following functions make up the User Services Activities:

1) Data Collation
2) Montage and Mosaic
3) Data Classification
4) Research and Data Utilization
5) Browsing File
6) Catalog
7) User Services Center

The following sections discuss these activities in detail. More emphasis (in this report) has been placed on certain activities where the large amounts of data expected from the Earth Resources Technology Satellites must be efficiently handled.

4.3.1 Data Collation Activity

The data collation area is essentially an active warehouse. All of the functions of a warehouse are included. These are shown schematically in Figure 4-8 and listed below:

1) Receive photographic data from the PPL.
2) Distribute PPL products to internal center functions and to external User Analysis centers.
3) Receive DCS data from the DCSM and distribute as specified.
4) Receive and file or distribute, as required, various computer printouts, listings, etc., generated by T&DS, etc.
5) Provide internal document duplication services.
6) Provide catalog preparation services for DCC and the montage area.
7) Provide clerical support services for the User Services Center.
8) Provide interface services between User Services and the remainder of the NDPF for data requests, public information, office support, etc.

4.3.2 Montage or Mosaic Activities

The montage preparation would begin with the delivery of the 70 mm RBV and MSS images from the PPL. Initially, montages covering the United States will be prepared. World montages may eventually be prepared. Montage boards would be prepared before the arrival of the imagery. The NADUC techniques of montage preparation would be applied.

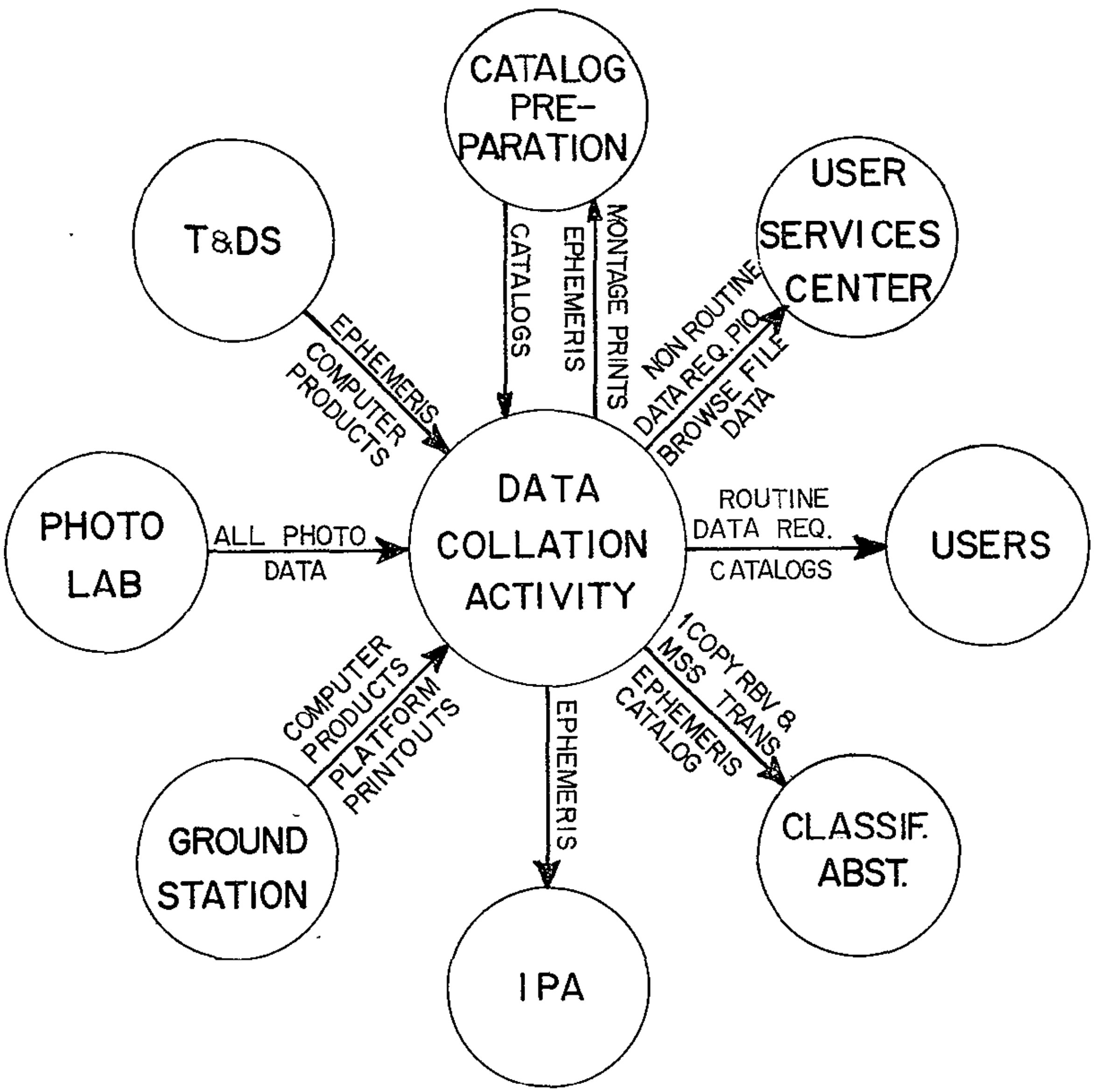

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Figure 4-8 Data Collation Activity Functional Data Flow

The montage area would begin to receive the 70 mm contact prints as soon as routine production is started in the PPL. Figure 4-9 presents a general picture of the montage preparation data flow. The montage boards, prepared prior to the arrival of the imagery, contain subpoint track and image location information. The montage technician merely places individual trimmed 70 mm images in the proper location on the board. After the montage board has been photographed, the film is developed and distributed to the catalog preparation area and to the User's Service Center.

4.3.3 Data Classification Center

Classification of the quality of the image content and the amount of cloud obscurement is an essential part of the communication responsibility for the ERTS Photographic Data Management System. External (nonroutine) users may often select images for retrieval on the basis of (1) a review of the montages, and (2) the statement of image quality and cloud cover presented in the data classification catalog. Therefore, the classification activity is a significant element of the total system. We have, however, specified a very limited type of data classification. Any extension of the classification requirements may increase the overall work load.

4.3.3.1 Classification Items

The following items should be included in the catalog. The suggested format both for recording them and for publishing them in the data catalog is shown in Figure 4-10.

<u>Data Orbit Classification Information</u>

1) Satellite
2) Day, Month and Year (of data orbit)
3) Data Orbit (on which imagery is recorded)
4) Descending Node (of data orbit)
5) Descending Node Zone
6) Corresponding Magnetic Source Tape
7) Data Orbit Remarks

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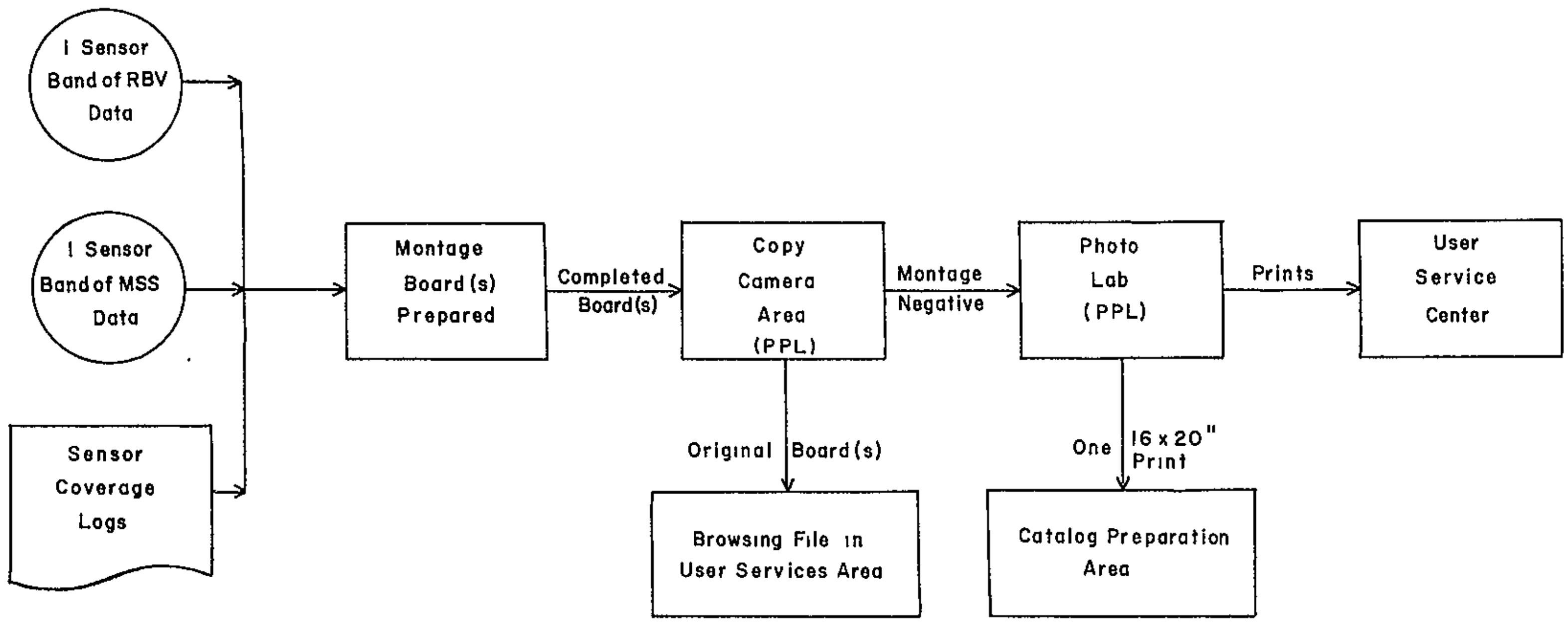

Figure 4-9 Montage Procedures -- Functional Data Flow

SATELLITE	ORBIT INFORMATION: DAY MONTH AND YEAR	ORBIT	DESCENDING NODE LONGITUDE	DESC. NODE ZONE	CORRESPOND'G MAGNETIC TAPE	Data Orbit Remarks

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

FRAME INFORMATION

FRAME NUMBER	PICTURE TIME	RBV & MSS FRAMES AVAILABLE	SATELLITE SUBPOINT LATITUDE	SATELLITE SUBPOINT LONGITUDE	SATELLITE ALTITUDE	SUN ANGLE	HEADING ANGLE	GRID CORRECTION	GRID CHECK CHANNEL	CLOUD FREE AREA BY QUADRANT	ATMOSPHERIC OBSCURATION BY QUADRANT	COLOR COMPOSITE	Data Content Remarks

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Figure 4-10 ERTS Data Classification Log Form

Data Frame Information

1) Frame Number
2) Picture Time
3) RBV and MSS Spectral Bands Actually Recorded (1 available, 0 not available)
4) Latitude and Longitude of Satellite Subpoint (at picture time)
5) Satellite Altitude (at picture time)
6) Sun Angle (at satellite subpoint location)
7) Satellite Heading Line (at picture time)
8) Grid Correction (amount computer superposed grid coordinates differ from real ground position)
9) Sensor Band Used for Grid Correction

Data Quality and Content Information

1) Cloud-Free Amount by Frame Quadrant
2) Atmospheric Obscuration of Ground Features by Frame Quadrant
3) Color Composite Available (yes/no)
4) Concise Statement on "Significant" Terrestrial Information

4.3.3.2 Data Sources

The source data used by the classification specialists will be:

1) Copies of the three RBV and four MSS images received routinely from the PPL.
2) Computer listings of the significant elements of the imagery, such as sun angle, spacecraft attitude, etc.
3) Image annotation revisions, data collection platform location, etc., transmitted from the IPA activities.

4.3.3.3 Classification, Data Flow and Procedures

The general flow of data through the Data Classification area is depicted in Figure 4-11. A single-channel classification procedure is presented. The other channels should be displayed for review. The sensory data images for all RBV and MSS channels arrive from the PPL in a positive transparency format (preferably 70 mm). Associated computer listings may be delivered from several

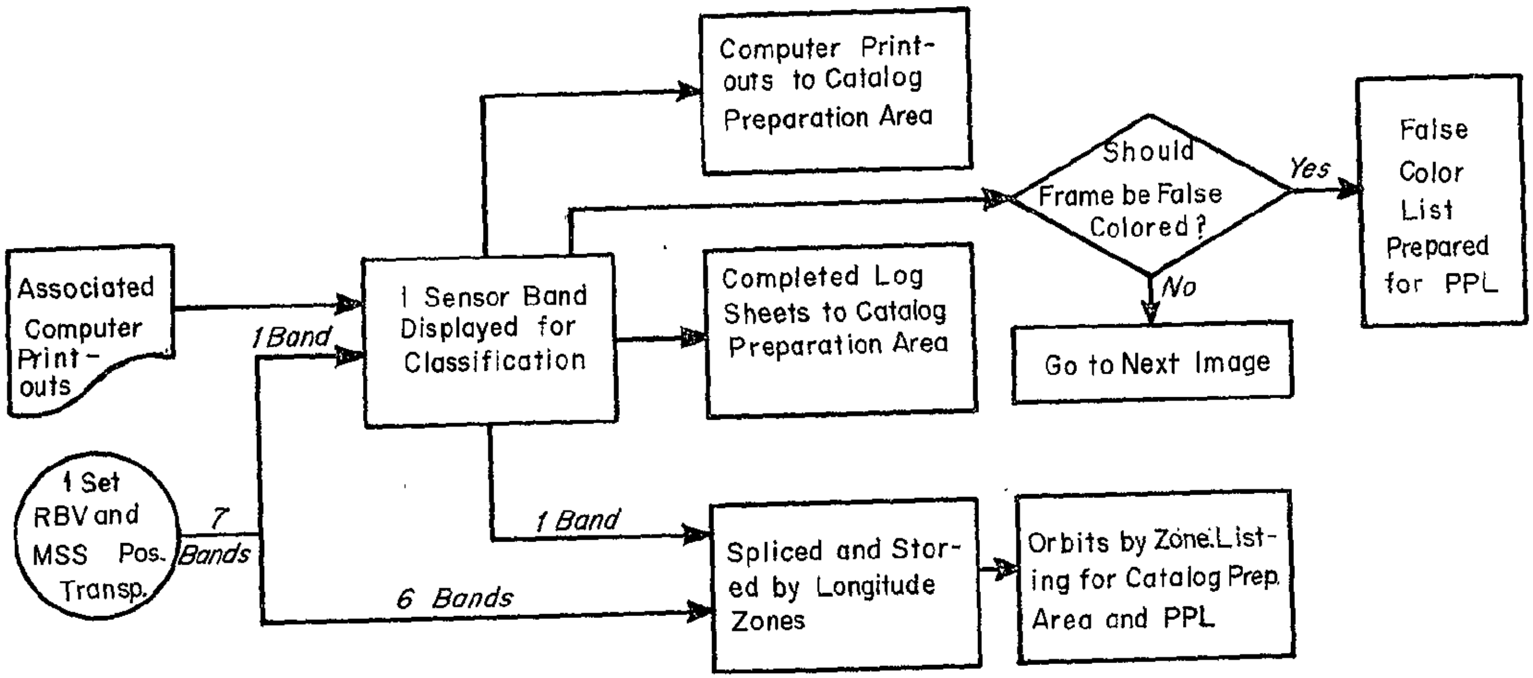

Figure 4-11 Data Classification Center Functional Data Flow

sources. The primary input will be from the IPA area. There are at least two possible procedures to classify each data set. One method would classify one sensor band of the seven sensor bands available. (The other six would be displayed for guidance, but not classified.) The second method would classify each of the seven sensor bands and attempt a "resource" classification. Classification of cloud cover distribution, atmospheric attenuation and determination of picture principal point require only one spectral interval. We assume that one spectral interval, e.g., "green" can give a reasonable measure of atmospheric obscuration; the "blue" channel should be worse, the "red" better. If, however, the atmosphere obscuration is composed of larger than molecular-sized particles, the simple blue "worse"/red "better" rule will not apply. All channels should be viewed, but not all classified.

The procedures required to classify the data can be relatively simple and straightforward or they can become rather complex if detailed image analysis is performed on each data set.

A simple classification procedure is outlined in nine steps below:

1) All recorded image sets (three RBV and four MSS frames per set) and associated printouts are received in the classification area.

2) One sensor band is displayed in a viewer for analysis. The other channels are displayed for quick review.

3) A 1:1,000,000 (or smaller scale) topographic map coverage of the same area is displayed either in the same viewer or in an adjacent viewer.

4) The picture grid correction is determined. Match the geographic features in the imagery with the same features on a strip map overlay. The differences in coordinate locations between the image grid and the strip grid could then be recorded on the Classification Log form. Accuracies approaching 0.01° can be achieved with this system.*

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*If the principal points can be defined to $.01^{\circ}$ for each pass over a given area (every 18 days approximately), the orbit drift can be determined with a precision equal to the attitude determination accuracy. An optical-electronic system was developed for Nimbus; i.e., the Nimbus Photogrammetric Attitude System, which might, with modification, provide a means to compute attitude and determine orbital drift at the same time.

5) Cloud cover distribution is determined for each quadrant of the image. (The cross-hairs aligned on the image principal point conveniently quarter the picture.) Cloud amount (where the ground is completely obscured) would be determined in eighths or tenths of complete cloud cover. Distribution of these clouds within each quadrant would be noted. The remainder of each quadrant would have the ground visible to some degree. The information on the noncloud-covered portion could be presented as a sequence of four numbers, each being an estimate of the noncloud-covered portion in a quadrant (in eighths or tenths). For example, 6187 could mean 6/8 not cloud covered (or 2/8 cloud cover) in quadrant 1; 1/8 ground visibility in quadrant 2; clear or total ground visibility in 3; 7/8 in 4.

The ground (where no clouds exist) could be sharply visible, hazy or partially obscured by thin clouds. This quantity, when classified, would be called the "atmospheric obscuration to vision of each quadrant." It would indicate the general clarity with which the noncloud-covered portion of the earth in each quadrant could be viewed. The Manual of Photographic Interpretation indicates that five levels of clearness can be identified from ground observations. Table 4-19 proposes a similar five-level categorization system for ERTS image classification.

TABLE 4-19

IMAGE QUALITY ASSESSMENT

Code	Degree of Obscuration	Definition
1	No obscuration to vision	No apparent contrast* reduction
2	Light obscuration to vision	Contrast reduced in low contrast areas
3	Moderate obscuration to vision	Contrast reduced in both low and moderate contrast areas
4	Heavy obscuration to vision	Only high contrast areas visible
5	Not determinable	

*The use of contrast reduction refers to previous apparently clear imagery in the same area. It is entirely a subjective assessment. It may be possible to use a micro-densitometer to define a semiquantitative value for obscurations to vision in the future.

The atmospheric obscuration would be coded as the level of obscuration averaged over the noncloud-covered area of each quadrant; e.g., if 6187 is the ground-visible code, the obscuration might indicate 2321. This would indicate that 6/8 of quadrant 1 is affected by a light obscuration, Code 2; 1/8 of quadrant 2 has moderate obscuration, Code 3; 8/8 of quadrant 3 has a light obscuration and 7/8 of quadrant 4 has no obscuration. Remarks could be used to delineate point source noncloud obscurations such as smoke-plumes, etc.*

6) At this point, the frame of data would be classified and the imagery would then be advanced to the next frame for classification.

7) Upon completion of classification of a data orbit, the seven bands of sensor imagery (including the one used for analysis) would be spliced onto reels in the appropriate zone for browsing file storage and retrieval.

8) The completed log sheets would be forwarded to a catalog preparation area.

9) The classification analyst would determine which images the Photographic Laboratory should process in a routine** color format. This list will be forwarded to the PPL job control for processing. The list of color composites would be included in the classification catalog.

4.3.3.4 Data Content Classification

The data volume, time and the limited number of analysts at the Data Center will certainly preclude complete analysis of the imagery. However, it is anticipated that concise remarks on "significant" or unusual events recognized and understood by the analysts will be recorded.

Table 4-20 lists examples of the kinds of Data Content Classification comments envisioned.

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*Nimbus Data Utilization Center (NADUC) personnel were asked to estimate, from 70 mm Apollo IX images, (which have 75 n.mi. square coverage per frame) the cloud-free amounts and atmospheric obscurations. In 65% of the quadrants sampled the analysts' estimates of cloud-free amounts were within 10% of each other (1/10 cloud cover difference). Eighty-six percent of the time the estimates were within 20% of each other (2/10 or less cloud cover difference). In 85% of the quadrants sampled, the analysts agreed, to within one value on the degree of "atmospheric obscuration of ground detail." Average analysis time per frame was 15 seconds.

**Routine color composites will include only those color combinations that are previously described by the appropriate users. Designation of routine requirements for color compositing should be accomplished in the near future.

TABLE 4-20

EXAMPLES OF DATA CONTENT CLASSIFICATION REMARKS

New snowfall pattern in Iowa and Kansas
Ice Jam on Mississippi River near La Crosse, Wisconsin
New ice in Saginaw Bay, Michigan
Decrease in Ft. Peck Reservoir coverage (reference orbit 733 for previous coverage)
Recent rainfall pattern in Colorado
Flooding along North Platte River (0.8 to 1.1 μm MSS channel)
Lake Erie pollutant or sediment swirls prominent
New forest cutting evident near Phillips, Wisconsin
Forest fire of 1000 acres extent Adirondack Mountains
Apparent widespread disease or stress pattern in forest near Bangor, Maine
Northward march of forest bloom evident (compare with data orbits 373 and 629)
Fall defoliation change from previous coverage of area
Good correspondence between map limits of corn belt and ERTS imagery (frames 6 through 9)
Effects of summer drought in Mississippi on cotton growth evident in time series using orbits 629, 942 and 1105
Apparent winter wheat planting pattern in the Dakotas distinguishable
New interstate road through Arkansas evident
Rapid suburban development around Washington, D. C. (compare with coverage from last year)
Smog pattern over Detroit
Oil fields in Texas
Messabi Range open pit mines
Evidence of tornado damage in Abilene, Texas
Hebgen Lake earthquake and landslide visible

TABLE 4-20, continued

Excellent example of mountain glacier features
Nevada playas with recent rainfall (compare with orbit 729)
Evidence of shoreline changes caused by Hurricane Beulah
Apparent increase in sand dune area around Saint Louis Obispo Bay, California
Image gray shades seem to correlate well with soil map of Oregon
Kelp beds visible
Sediment defined eddy patterns in Galveston Bay, Texas
Oil slicks off Louisiana Coast
Chlorophyll concentration of Oregon Coast

Columns 50 through 80 on the Classification Log Sheet would be reserved for these data content remarks with a corresponding amount of space reserved in the Data Catalog for the same purpose.

4.3.3.5 Alternate Proposal for Data Content Classification

Earlier work suggested a resource classification scheme utilizing four-digit numbers in a logic tree system to classify ERTS geophysical data (see Appendix A of Merritt et al. 1969). As an experiment, an inhouse effort should be conducted, after ERTS launch, to see if this scheme is practical. If it appeared useful and practical, then it could be included in succeeding data catalogs. Past experience with a data classification and retrieval scheme for Nimbus data at the NADUC* has indicated that only a few users found such a system applicable to their needs and, consequently, they ignored the classification system when requesting data. Therefore, because it is felt that the benefits and usefulness of this system could be small for the amount of time expended, this scheme should be tested and refined as an inhouse effort before it is included in a data catalog.

There may be more usefulness in a few, brief comments on items of "significance" than in a very general numerical classification of all observed phenomena.

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*Hopkins, M. M., Jr., 1967: "An Approach to the Classification of Meteorological Satellite Data," J. of Appl. Meteor., 6, 1, (Contract NAS 5-3253); also, Hopkins, M. M., Jr., and A. H. Glaser, 1965: Recommended Formats for Sensory Information Processing Program, Tech. Note. 5; NAS 5-3253, ARACON Geophysics, Allied Research Associates, Inc.

4.3.3.6 Classification Equipment

1) Two vertically mounted viewing tables, each capable of handling and displaying at least four reels of 70 mm film.* Each displayed image should be about 8" x 8". (One viewer would be used for current data; the other for viewing previous images of the same area.)

2) One vertically mounted viewing table for display of 1:1,000,000 topographic (and other thematic) maps stored on 70 mm color film.

3) Stereoscope for viewing 8" x 8" positive color prints.

4) Projection device to transfer ERTS imagery to base map scales between 1:5,000,000 and 1:250,000.

5) Variable scale device (similar to Gerber Scale) capable of measuring in 600 ft increments on an 8" x 8" print.

6) Medium power microscope (with calibrated glass to lay over 70 mm images) for fine scale analysis.

7) Area measuring device (could be built into viewing device, stereoscope and/or attached to microscope).

8) Storage and print device. Used to store all data classification and abstraction information so that an analyst in the classification area could quickly recall past information about the area he is currently classifying. Alternatively, an up-to-date catalog printout should be available for the data classifiers.

4.3.4 Research and Data Utilization Support

The main cadre of geoscientists in the ERTS Data Center will reside in the User Service area. The personnel will be intimately involved in data classification. A significant effort of the cadre will be in support of various user requests. Additional tasks to be performed include: (1) The support of various data utilization experiments, and (2) utilization-directed research. The following will discuss each of these tasks, and attempt to define their relation to the well-being of the ERTS Data Center specifically, and to the ERTS program in general.

*The use of 17" x 22" film for the MSS data was investigated but is not recommended.

4.3.4.1 Data Utilization Experiment Support

Specification of the economic and management benefits which may be expected from an operational Earth Resources satellite can only be derived from the day-to-day use of the information gathered from an experimental system such as ERTS. A series of Data Utilization Experiments to use ERTS data on a regular operational basis is already planned by various user groups. The ERTS Data Center geoscientists can perform a useful role in these experiments. In the cases where the experimental program requirements specify interpretation of the sensory data "in the field," the ERTS geoscientists can provide a knowledgeable interface with the production phases of the Data Center. In this interface role they would monitor the appropriateness of the data for specific uses. For example, in a "Water Availability" experiment where the users would be seeking to evaluate the existence and extent of the surface water distribution, the ERTS Data Center geoscientists would provide a monitoring function to assure that the imagery sent to the users was suitable for the job.

4.3.4.2 Utilization-Directed Research

Experience with NADUC has demonstrated the value of internally developed studies, displays, etc., to stimulate new data uses (see Sabatini and Sissala, 1968).

Similarly, an important aspect of internal research activities is the routine evaluation of sensor performance. Research analyses, including evaluation of ground-truth information and of the sensory data returned by ERTS, is essential to performance of this task. (See also, Sabatini and Rabchevsky, 1970; Technical Report No. 16, Vol. II, Contract NAS 5-10343.)

4.3.5 Browsing File Preparation

Of the two sets of RBV and MSS positive transparency imagery received from the PPL, one will be utilized in classification while the second will be formatted for browsing file display projectors proposed for use in the User Services Center. It is assumed that the two sets will be formatted in the same manner as is used for the archival and working master storage and retrieval (see Section 4.2.10). The film is arranged such that each channel of the RBV and MSS will be accumulated on separate 500-ft reels holding 16 passes (obtained over 290 days) over the same geography.

4.3.6 User Services Center (USC)

The User Services Center forms the main point of contact of the ERTS Data Center with the outside user community. The USC functions include:

1) Processing of data requests.
2) Preparing and maintaining a display area/work area for visiting users to review the ERTS imagery.
3) Provide familiarization briefings on the services available in the Data Center and publish supplementary information to assist users in data interpretation. (This function will be assisted by the User Services Support Group of the Data Classification Center.)
4) Mission planning - cloud cover prediction evaluation.

4.3.6.1 Data Requests

Data requests can take many forms from routine mail requests for photographic products to special requirements posed by an investigator visiting the Data Center. Figure 4-12 provides a generalized picture of the steps which may be involved in servicing user requests.

4.3.6.2 Display File/Work Area

The User Service Center will be responsible for establishing and maintaining a display file (browsing file) and work area. Display projectors for efficient viewing of the 70 mm imagery are a requirement. Additional materials that should be available for use include:

1) The original montage boards and 16" x 20" copies.
2) Copies of any appropriate false color composites.
3) Copies of the various catalogs, User's Guide, Montage and Classifications.
4) Orbital listings and required working tools should also be available. They may include:
    - Light tables
    - Variable scales

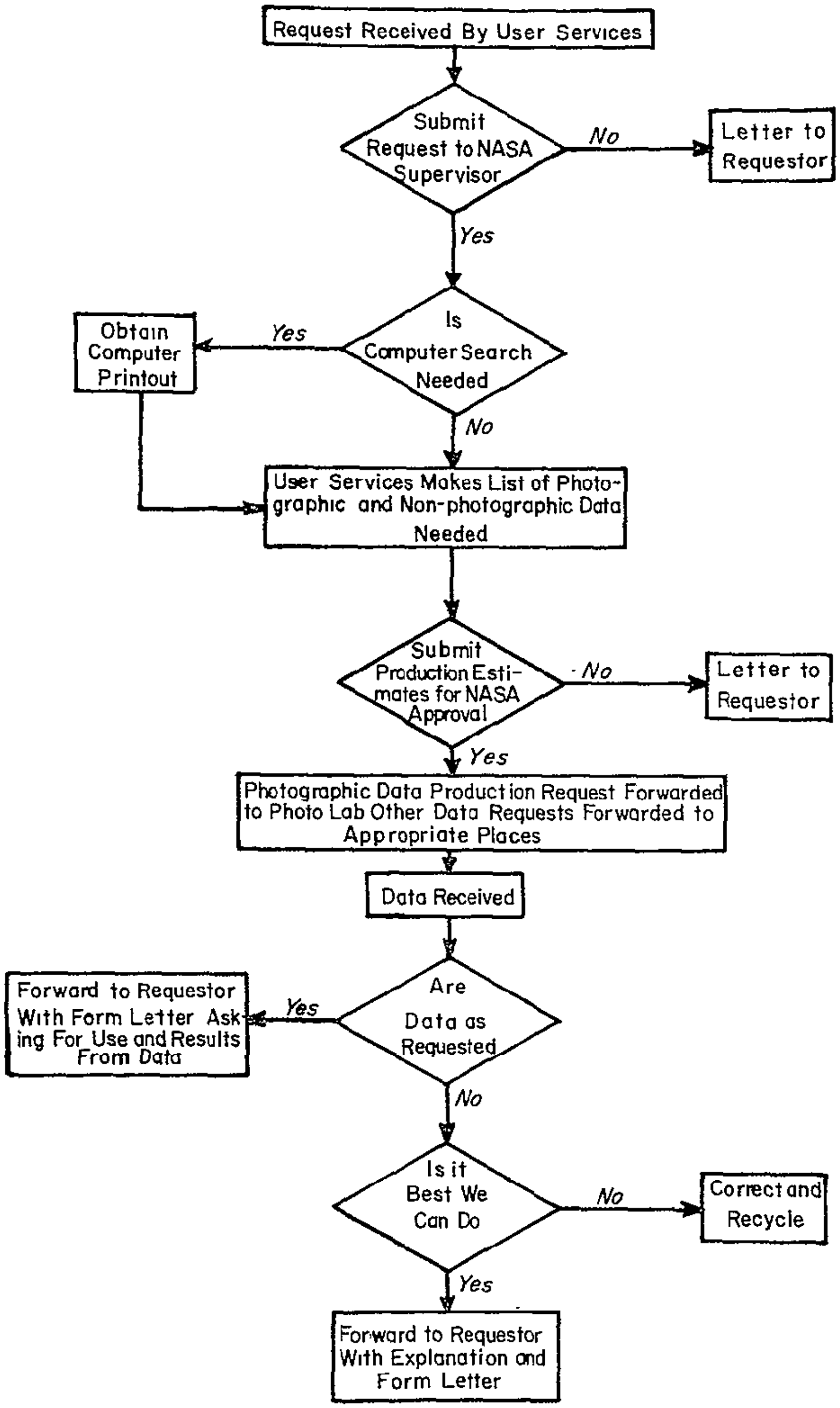

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Figure 4-12 User Request Processing Procedures

- Magnifiers
- Atlases
- Reference materials
- Expendables (pencils, paper, etc.)
- Duplication facilities (Xerox, Polaroid, etc.)
  (The duplication facilities will be available in the Data Collation Activity.)

4.3.6.3 Publication of User's Aids

These may be thought of as addenda to the User's Guide*, and will be published periodically as the need arises. Examples would be:

- New false color methods
- Graphical gridding methods for large attitude errors, etc.

4.3.6.4 Mission Planning and Cloud-Cover Predictions

Sensor on-time predictions for land coverage can be prepared as a function of ascending node longitude. All that is needed is an orbital track with a time scale referenced to the equator crossing and a map on which to overlay this orbital track.

Sensor on-time predictions that will exclude cloudy areas could be prepared by transposing predicted cloud positions to a base map on which an orbital track can be overlayed. Satellite cloud pictures, ESSA predictions, and weather maps would be used to evaluate cloud coverage. Areas of high cloud probability can be indicated on the base map. The mission planning section would maintain an accounting of picture coverage as a function of area. If an area has had little coverage, pictures should be attempted, even if there is a high probability of cloudiness. The planning section can also confer with the ERTS Mission Director to evaluate and plan for user's data requests.

4.3.7 Catalog Preparation

The primary method of ERTS Data Center communication with the external user community is through the regular assembly and dissemination of ERTS Data Center catalogs.

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*See Section 4.3.7.1.

The types of catalogs include:

1) An ERTS User's Guide

2) An ERTS Sensory Data Classification and Orbital Montage Catalog

4.3.7.1 User's Guide

Since one objective, perhaps the most important one, of the ERTS Data Center is communication of ERTS data to the user community, there is a requirement to provide the users with the details of the ERTS sensor system, operational procedures and Data Center procedures. In the Nimbus and ATS operational this requirement has been met with a User's Guide. This guide, prepared in cooperation with the NASA sensor experimenters, is issued prior to the launch of the satellite. It provides the user with the information he needs for efficient understanding of the total data system.

An ERTS User's Guide would be a valuable communication tool. Preparation of the guide would be delegated to the scientific and engineering staff in the Data Center. Actual responsibility could be placed on the Data Classification/User Support Group supervisor since he should have the best working understanding of the complete data system.

4.3.7.2 Sensory Data Catalogs

Two alternate forms are proposed for the Sensory Data Catalog. One approach suggests the publication of three separate catalogs:

1) A Sensory Data Classification Catalog
2) Data Abstraction Catalog
3) Montage Atlases

The second approach combines these three areas with data from:

1) The Data Collection Subsystem
2) Special Displays
3) Bibliography of ERTS Reports and Symposia
4) A Listing of Ground-Truth Experiments

Details of these two formats are included in Appendix A. The second approach is recommended and is therefore presented in greater detail.

5. QUALITY CONTROL STANDARDS AND PROCEDURES

Quality standards are the heart of a precision photographic processing system. Standards must be established for each major point in the photographic data flow. Therefore, a separate section of this report has been devoted to the discussion of necessary quality control standards and procedures.

5.1 Initial Processing and Data Evaluation

Data flow through the IPA is described in Section 4.1. The exposed, but undeveloped, RBV and MSS film is received from the Accounting and Sorting (A&S) activity into a central job control area. The sealed film cans are sent to the MPPL area and processed. The processed film is then checked with a densitometer* to assure that the proper dynamic range has been achieved. If the film does not pass the quality check, the System Analysis group should be asked to check the type of problem that may exist. In a few cases, it may also be decided to ask for a display rerun.

Film which passes the quality check will then be used to prepare one black and white contact print. The original film, in resealed cans, is delivered for interim hold storage. The contact print will then pass through the various IPA steps outlined in Section 4.1. After the IPA activities are completed, the archival film will be delivered from Interim Storage through Job Control to the PPL. The PPL will then prepare duplicate working masters (one positive and one negative). After quality checking, the working masters will be delivered to the Reproduction Film Library for cataloging and indexing. The original archival master will be sent to a permanent Archival Storage area.

The working masters will be sent via Job Control for further reproduction; i.e., Routine Production, PIO and special requests. Job Control will supervise delivery of data and the return of the working master to the Reproduction Film Library.

Black and white precision reproductions and color composites for selected imagery will be prepared on the basis of a list delivered to Job Control from the Classification Center. The appropriate film is retrieved from the Reproduction Film Library and cycled through the reproduction and quality check flow before being returned to the library.

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*A scanning densitometer could be used to check the uniformity across the film. There appears to be no real requirement for a scanning system.

Montage preparation and copy will be prepared outside the reproduction area but will also cycle through reproduction and quality checks via Job Control.

5.2 Photographic Data Quality Control Procedures

5.2.1 Image-Display Processing Standards

Quality assurance procedures for the ERTS Data Center photographic functions begin in the image display area of the NDPF. It is at this point that the transfer is made from a magnetic tape to photographic film. Routine quality assurance standards must be established and maintained from this point on. It is anticipated that the standards will be established by the Photographic Process Supervisor after thorough discussion with the appropriate NASA personnel. Once the standards are established, the Master Photographic Processing Laboratory (MPPL) will perform the control measurements. Unacceptable imagery will be referred back via an appropriate management structure for correction.

5.2.2 Cleanliness in Film Handling

An integral factor in the production of a high-quality photographic product is cleanliness. Personnel required to handle film must wear cotton gloves of a type prescribed for film-handling use, "Static Master" type brushes and air syringes for the removal of dust or dirt from the film surface, and work in an area that is kept meticulously clean. Film cleaning solutions should be used to remove particles not removable by brushing. Unnecessary or excessive amounts of film handling, especially of archival film, must be avoided.

5.2.3 Monitoring of MPPL and PPL Processors, Sensitometry, Densitometry and Chemistry

The monitoring of the various automated processors should be performed prior to each time materials are introduced into the processor. Additional quality-control checks should be performed following each chemistry change or adjustment.

The highly sensitive and sophisticated instruments used in monitoring and control of film and paper processors also require conscientious monitoring. These instruments must be frequently checked and recalibrated to assure continued accu-

racy in the maintenance of the established quality control standards. The information applicable to these checks must be entered on the the AIM Value Work Sheet, Control Value Table, Electronic Densitometer Record, and Daily Record Form (Figures 5-1 through 5-4, as appropriate).

A quantitative analysis of the black and white processing chemistry must be performed daily and, as indicated by trends in the composite of the characteristics curves, appropriate adjustments can then be accomplished, and all pertinent data entered in the sensitometric data log (Figure 5-5). A quantitative analysis of the color chemistry must be performed daily and at additional times as required.

A quantitative analysis must also be made of each replenishment mix (color and black and white) prior to its introduction into the replenishment storage tanks, to assure its compatibility with the system.

Preventative and routine maintenance to automated film and paper processors, including cleaning as recommended by the manufacturers, are essential to their continued qualitative performance. A repair and spare parts shop should be integrated with the PPL and appropriate personnel trained to handle this function.

5.2.4 Establishment of Standards

The establishment of realistic standards for the quality of various types of ERTS data, and optimum settings for photographic developing and processing equipment, are both difficult and subjective. At this point it is only possible to suggest standards based upon experience acquired from previous operations and empirical knowledge on certain photographic and electronic equipment.

Automated Quality Control

All control procedures described are based upon the assumption that Quality Control operations will be utilizing instrumentation that will require manual reading and recording. It is estimated that an experienced quality-control operator takes approximately 5-1/2 minutes to read, record and plot an average control strip.

It is suggested that automatic quality control instrumentation be employed where practicable. Such instrumentation would provide control consistency and reduce readout and plotting time to as little as 7 seconds per control strip.

AIM VALUE WORK SHEET
(Electronic Densitometer)

Densitometer No. RD-100 Check Plaque No. 70557

20-Day Base Period: SEPT. 1 through SEPT. 29, 1970.

DATE	CHECK NO.	COLOR			PHOTOMETRIC		
		RED	GREEN	BLUE	RED	GREEN	BLUE
9/1	1	1.37	.68	.57	1.79	1.74	1.69
9/2	2	1.40	.67	.56	1.78	1.75	1.70
9/3	3	1.40	.68	.58	1.76	1.74	1.68
9/4	4	1.40	.67	.57	1.76	1.74	1.69
9/8	5	1.41	.69	.58	1.79	1.76	1.72
9/9	6	1.39	.67	.57	1.78	1.77	1.70
9/10	7	1.40	.68	.58	1.78	1.76	1.70
9/11	8	1.39	.68	.57	1.77	1.75	1.70
9/14	9	1.39	.68	.57	1.77	1.75	1.69
9/15	10	1.39	.68	.57	1.78	1.76	1.70
9/16	11	1.39	.67	.56	1.77	1.75	1.69
9/17	12	1.40	.68	.58	1.78	1.76	1.71
9/18	13	1.38	.67	.56	1.76	1.74	1.69
9/21	14	1.40	.67	.57	1.77	1.74	1.69
9/22	15	1.39	.67	.57	1.78	1.75	1.69
9/23	16	1.39	.67	.57	1.79	1.76	1.70
9/24	17	1.38	.68	.58	1.78	1.75	1.69
9/25	18	1.39	.67	.57	1.77	1.75	1.69
9/28	19	1.38	.67	.57	1.77	1.74	1.69
9/29	20	1.38	.67	.56	1.76	1.74	1.68
	TOTALS	27.82	13.50	11.41	35.49	35.00	33.89
AVERAGES (÷20)		1.39	.675	.57	1.77	1.75	1.69

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Figure 5-1 Example of Work Sheet Used to Monitor Densitometer Stability

CONTROL VALUE TABLE

Densitometer No. RD-100 Aim Values Established (date) 9/29/70

COLOR CHECKS							PHOTOMETRIC CHECK				
Filter Status A				Filter Status							
Red D.D.*	Green D.D.	Blue D.D.	Control Value	Red D.D.	Green D.D.	Blue D.D.	Red	Green	Blue	Control Value	
1.43	.71	.61	9.0				1.81	1.79	1.73		
1.42	.70	.60	5.1				1.80	1.78	1.72	9.0	
1.41	.69	.59	2.2				1.79	1.77	1.71	4.0	
1.40	.68	.58	0.6				1.78	1.76	1.70	1.0	
1.39	.67	.57	0.0				1.77	1.75	1.69	0.0	Aim Values
1.38	.66	.56	0.6				1.76	1.74	1.68	1.0	
1.37	.65	.55	2.2				1.75	1.73	1.67	4.0	
1.36	.64	.54	5.1				1.74	1.72	1.66	9.0	
1.35	.63	.53	9.0				1.73	1.71	1.65		

*Density Difference

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Figure 5-2 Example of Table Presenting Working Control Values for Color Filter Stability and Photometric Stability

ELECTRONIC DENSITOMETER RECORD FORM

Period: SEPT. 14, through SEPT. 29, 1970.

Densitometer No. RD-100
Check Plaque No. 70557

DATE		CHECK	PHOTO.[1]	C.V.[2]	CHECK	PHOTO.	C.V.	DATE	REMARKS
SEPT. 14, 1970	Red	1.38	1.77	0.6 / 0.0	1.39	1.77	0.6 / 0.0	SEPT. 22, 1970	
	Green	.67	1.74	0.0 / 1.0	.67	1.75	0.0 / 0.0		
	Blue	.56	1.68	0.6 / 1.0	.57	1.69	0.0 / 0.0		
	Control Value Total			3.20	C.V. Total		0.0		
SEPT. 15, 1970	Red	1.39	1.77	0.0 / 0.0	1.39	1.77	0.0 / 0.0	SEPT. 23, 1970	
	Green	.67	1.75	0.0 / 0.0	.67	1.75	0.0 / 0.0		
	Blue	.57	1.69	0.0 / 0.0	.57	1.69	0.0 / 0.0		
	Control Value Total			0.0	C.V. Total		0.0		
SEPT. 16, 1970	Red	1.39	1.77	0.6 / 0.0	1.39	1.77	0.0 / 0.0	SEPT. 24, 1970	
	Green	.67	1.75	0.0 / 0.0	.68	1.75	0.6 / 0.0		
	Blue	.57	1.69	0.0 / 0.0	.57	1.69	0.0 / 0.0		
	Control Value Total			0.0	C.V. Total		0.6		
SEPT. 17, 1970	Red	1.39	1.77	0.0 / 0.0	1.39	1.77	0.0 / 0.0	SEPT. 25, 1970	
	Green	.67	1.75	0.0 / 0.0	.67	1.75	0.0 / 0.0		
	Blue	.56	1.69	0.6 / 0.0	.57	1.69	0.0 / 0.0		
	Control Value Total			0.6	C.V. Total		0.0		
SEPT. 18, 1970	Red	1.39	1.77	0.0 / 0.0	1.39	1.77	0.0 / 0.0	SEPT. 28, 1970	
	Green	.67	1.75	0.0 / 0.0	.67	1.75	0.0 / 0.0		
	Blue	.57	1.69	0.0 / 0.0	.57	1.69	0.0 / 0.0		
	Control Value Total			0.0	C.V. Total		0.0		
SEPT. 21, 1970	Red	1.39	1.77	0.0 / 0.0	1.39	1.77	0.0 / 0.0	SEPT. 29, 1970	
	Green	.67	1.75	0.0 / 0.0	.67	1.75	0.0 / 0.0		
	Blue	.57	1.69	0.0 / 0.0	.57	1.69	0.0 / 0.0		
	Control Value Total			0.0	C.V. Total		0.0		

[1] PHOTOMETRIC [2] CONTROL VALUE

Figure 5-3 Example of Daily Work Sheet for Reflection Densitometer Monitoring

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DAILY RECORD FORM

Densitometer No. TD-102		Date- 9/21/70		Date- 9/22/70		Date- 9/23/70		Date- 9/24/70		Date- 9/25/70		Date- 9/28/70	
		Density	C.V.*	Density	C.V.	Density	C.V.	Density	C.V.	Density	C.V.	Density	C.V.
PHOTO. † CHECK	Red	3.00	0.0	3.00	0.0	3.00	0.0	3.00	0.0	3.00	0.0	3.00	0.0
	Green	2.90	0.0	2.90	0.0	2.90	0.0	2.90	0.0	2.90	0.0	2.90	0.0
	Blue	3.01	0.0	3.01	0.0	3.01	0.0	3.01	0.0	3.01	0.0	3.01	0.0
COLOR CHECKS (1st Status)	Red 1R	2.20		2.20		2.20		2.20		2.20		2.20	
	2R	.45		.45		.45		.45		.45		.45	
	D.D. (1R-2R) ≠	1.75	0.0	1.75	0.0	1.75	0.0	1.75	0.0	1.75	0.0	1.75	0.0
	Green 1G	1.09		1.10		1.09		1.09		1.09		1.09	
	2G	.91		.92		.91		.91		.91		.91	
	D.D. (1G-2G)	.18	0.0	.18	0.0	.18	0 0	.18	0 0	.18	0 0	.18	0.0
	Blue 1B	.83		.84		.83		.83		.83		.83	
	2B	1.55		1.56		1.55		1.55		1.55		1.55	
	D.D. (1B-2B)	.72	0.0	.72	0 0	.72	0.0	.72	0.0	.72	0.0	.72	0.0
	C.V. Total (22.5 max)												
COLOR CHECKS (2nd Status)	Red 1R												
	2R												
	D.D. (1R-2R)												
	Green 1G												
	2G												
	D.D. (1G-2G)												
	Blue 1B												
	2B												
	D.D. (1B-2B)												
	C.V. Total (27.5 max)												

*Control Value †Photometric ≠Density Difference

Figure 5-4 Example of Daily Work Sheet for Transmission Densitometer Monitoring

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SENSITOMETRIC DATA SHEET

PROJECT NO 7341 · DATE 9/21 - 9/24, 1970 INSTRUMENT TD-100 READER MOUNCEY

REMARKS

FILM TYPE	2420	2420	2420	2420	2420	2420	2420	2420	2420	2420	2420	2420
EMULSION NO	174-15	174-15	174-15	174-15	174-15	174-15	174-15	174-15	174-15	174-15	174-15	174-15
DEV.-TIME-TEMP	29/75	29/75	29/75	29/75	29/75	29/75	29/75	29/75	29/75	29/75	29/75	29/75
AGITATION	PUMP	PUMP	PUMP	PUMP	PUMP	PUMP	PUMP	PUMP	PUMP	PUMP	PUMP	PUMP
IDENTIFICATION NO	B-413	B-415	R-711	B-416	G-932	R-711	B-417	G-937	R-713	I-687	R-714	G-939
STEP NO 21	2.97	2.95	2.96	2.97	2.95	2.99	2.98	2.96	2.97	2.95	2.97	2.97
20	2.83	2.81	2.82	2.83	2.79	2.85	2.84	2.82	2.83	2.82	2.83	2.84
19	2.67	2.65	2.66	2.67	2.63	2.69	2.68	2.66	2.67	2.65	2.67	2.68
18	2.50	2.48	2.49	2.50	2.46	2.52	2.51	2.49	2.49	2.47	2.50	2.49
17	2.33	2.31	2.32	2.33	2.30	2.35	2.34	2.32	2.34	2.33	2.34	2.33
16	2.14	2.12	2.13	2.14	2.10	2.16	2.15	2.13	2.15	2.12	2.13	2.14
15	1.94	1.92	1.93	1.94	1.90	1.95	1.95	1.93	1.93	1.93	1.95	1.94
14	1.69	1.67	1.67	1.69	1.65	1.70	1.70	1.68	1.68	1.67	1.69	1.70
13	1.48	1.46	1.47	1.48	1.44	1.49	1.49	1.47	1.49	1.48	1.49	1.48
12	1.25	1.23	1.24	1.25	1.22	1.26	1.25	1.23	1.24	1.23	1.26	1.25
11	1.03	1.01	1.02	1.03	1.00	1.04	1.03	1.01	1.02	1.01	1.02	1.01
10	.81	.79	.80	.81	.79	.82	.81	.80	.80	.78	.81	.79
9	.62	.60	.61	.62	.59	.62	.62	.61	.63	.62	.63	.62
8	.45	.43	.43	.45	.42	.46	.45	.44	.45	.44	.43	.45
7	.31	.29	.29	.31	.28	.31	.31	.30	.30	.29	.31	.32
6	.20	.18	.18	.20	.19	.20	.19	.19	.20	.19	.20	.19
5	.13	.12	.12	.13	.12	.13	.12	.12	.13	.12	.13	.12
4	.09	.08	.08	.09	.08	.09	.09	.08	.09	.08	.09	.09
3	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06
2	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
1	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
FOG LEVEL	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03

Figure 5-5 Example of Data Record for Transposition to Gamma Plot Graph

5.2.4.1 Black and White Film

Quality control in the processing of photographic film requires strict adherence to established standards which are known to produce the density and contrast desired for a high-quality product. Control factors include processing time (speed) temperature and chemical replenishment rates. Specific criteria for these controls cannot be stated at this time, but must be determined after the initial photographic imagery has been received, analyzed and control parameters established. A set of criteria must be established to produce the prescribed measurements of density and contrast which will yield a consistently high-quality product.

Upon receipt of the exposed, unprocessed, RBV/MSS film,* a sensitometrically exposed 21-step gray scale, on the same type of film that is to be processed, is processed at the predetermined speed, temperature, and replenishment rate. Densitometric measurement of the 21 steps on the processed control strip are recorded in the sensitometric data log (Figure 5-6) and a characteristic curve plotted (Figure 5-7) to determine if the process is within control parameters of $\pm$.05 log density units. If the process is found to be out of control tolerances, corrective adjustments must be made to the chemistry and the procedure repeated until the desired control is obtained. The results of all such control checks, remedial action taken, and all other pertinent data should be entered in the sensitometric data log book. After controlled processing, densitometric measurements of the film are recorded and analyzed. If the results of these measurements indicate the imagery does not conform to the established standards, it should be forwarded to the Systems Analysis group to determine the type of problem that may exist, and a rerun may be requested.

5.2.4.2 Paper Prints

All paper prints produced in support of the ERTS mission must also be subjected to stringent photographic controls. The automatic paper processors must be continually monitored in much the same way as that outlined for film processing. The 21 steps of the sensitometrically exposed control strip, on a sensitized material of like kind to be processed, is measured with a reflection densitometer, appropriate records maintained, and corrective procedures followed when necessary.

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*All film, including subsequent reproductions, must be processed and handled under the same stringent procedures used with the archival copy, to achieve a uniformly high-quality product.

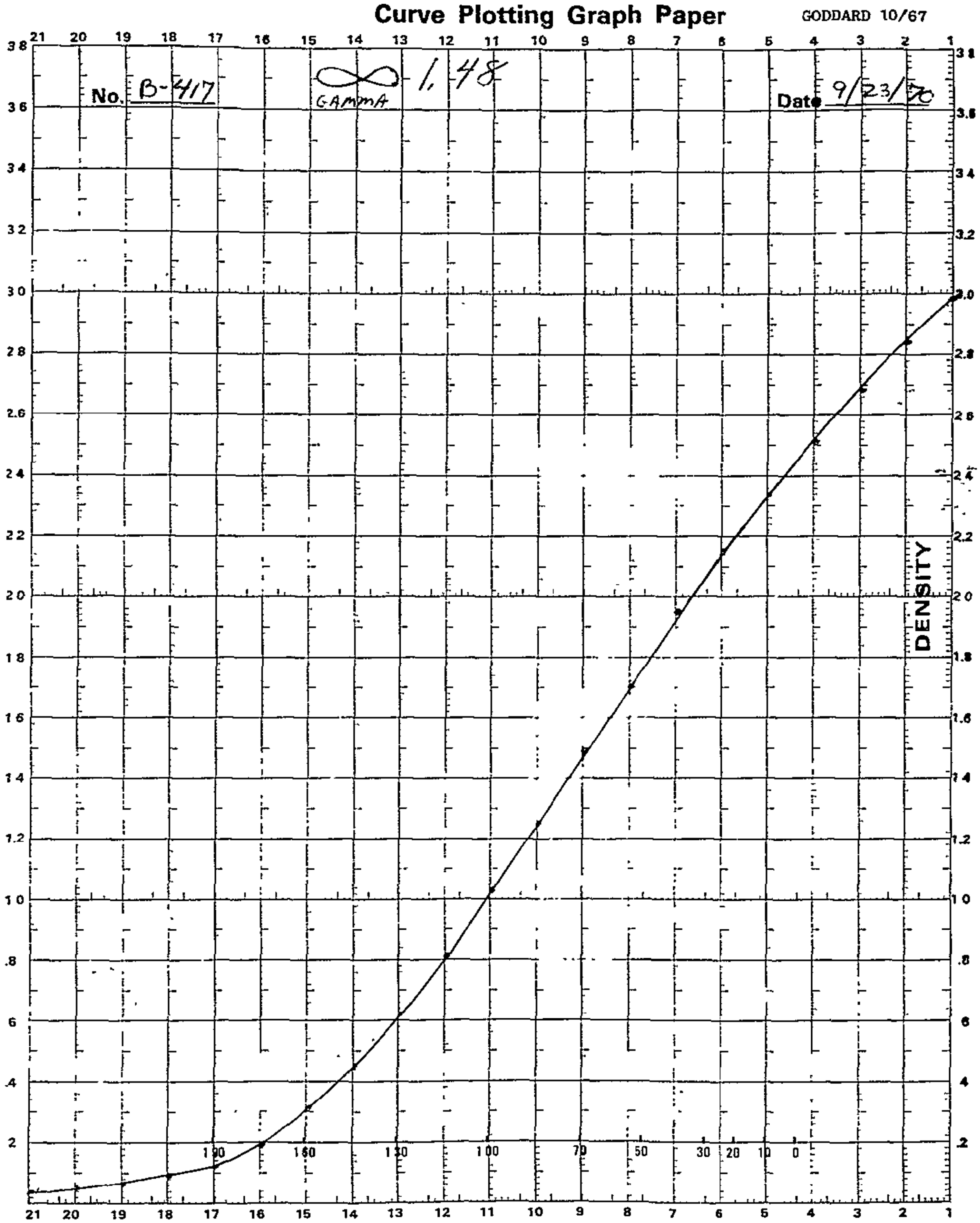

Figure 5-6 Example of Gamma Plot Graph Used to Monitor Process Control (Derived from a Transmission Densitometer)

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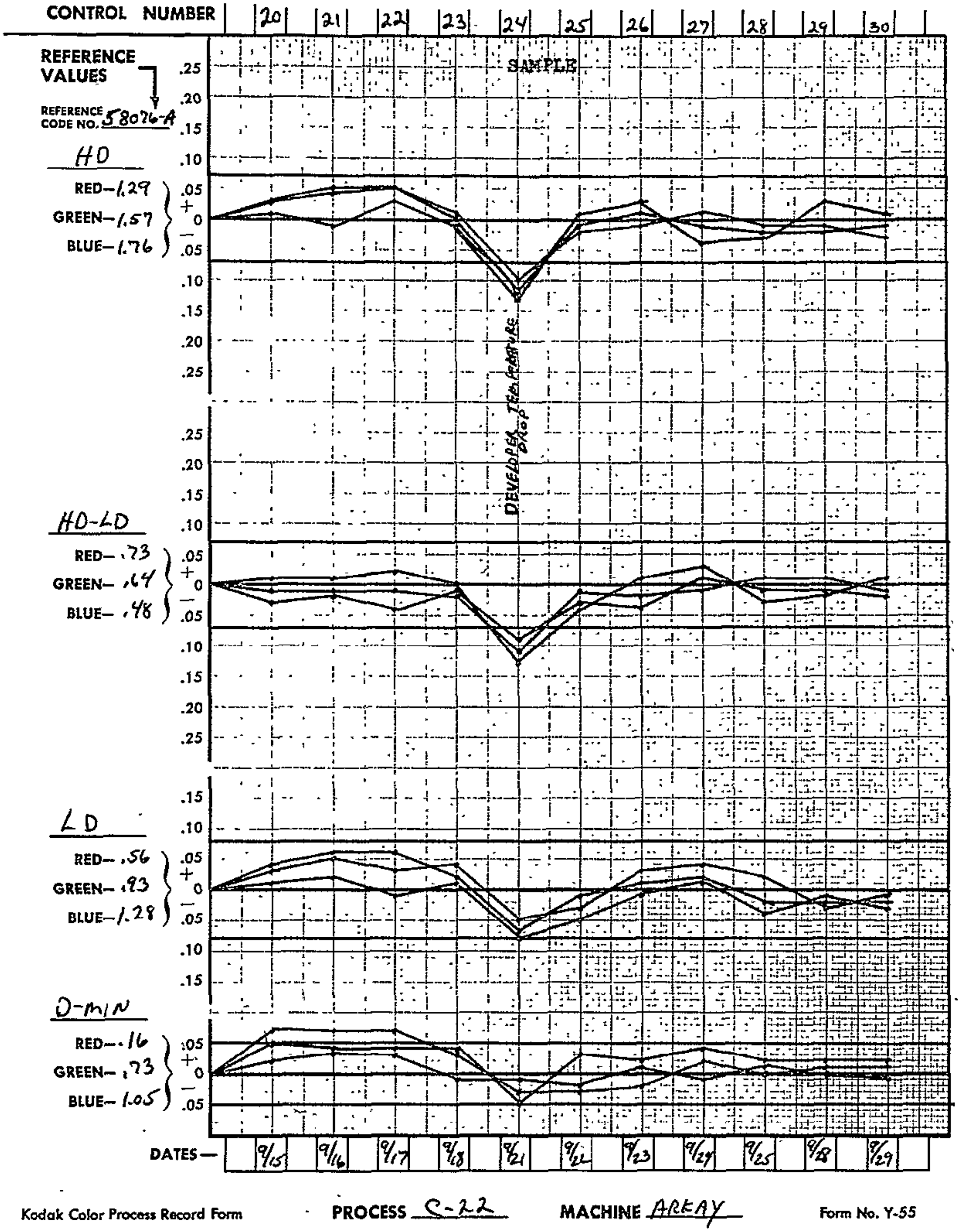

Figure 5-7 Example of Sensitometric Control Graphs for Color Film Processing Control (Derived from a Color Transmission Densitometer)

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Additional controls are introduced in the production of paper prints. These include exposure, contrast grade of the sensitized material and image enhancement production equipment. The critical eye of the production supervisor must be greatly relied upon to assure the proper integration of these controls to yield prints of consistently high quality.

5.2.4.3 Color Film and Prints

To assure success in processing, printing, drying and inspection of color products, a high standard of quality must be established. The quality standards should be such that the negatives, transparencies and prints have correct color balance and density, be free from physical damage, spotlessly clean and show none of the undesirable after-effects of incorrect processing.

The manufacturer's recommendations regarding chemistry and sensitized material have been proved in extensive laboratory and trade tests. To insure that the manufactuer's recommendations are followed, specifically and consistently, all color productions must be monitored systematically.

The monitoring system used to assure continued production of uniformly high-quality color prints, negatives and transparencies includes daily quantitative analysis of the chemistry in the processing line and requires the establishment of a reference standard with a conscientious systematic comparison of all production to this reference.

The reference, in a control system based on densitometry, consists of film or paper on which areas of specially selected densities have been exposed and which have been processed by the manufacturer. Control films or prints used to test daily photographic production must be exposed exactly as the reference. When processed correctly, these films or prints will show whether production conditions have changed since the reference was established. Then if an undesirable change has occurred, the recorded difference between the reference and control strips is used to determine what corrective measures must be taken. This record or control curve indicates if production is uniform from day to day, present condition of the processing solutions and if printing equipment is functioning properly.

Tolerance limits for color film and paper are established by the manufacturer of the sensitized material and chemistry. Figure 5-7 describes those limits for color film processing. Figure 5-8 describes those limits for paper processing.

The reference and control strips used to monitor the color film processing line contain high and low density patches and a D-Min area. Each one is read

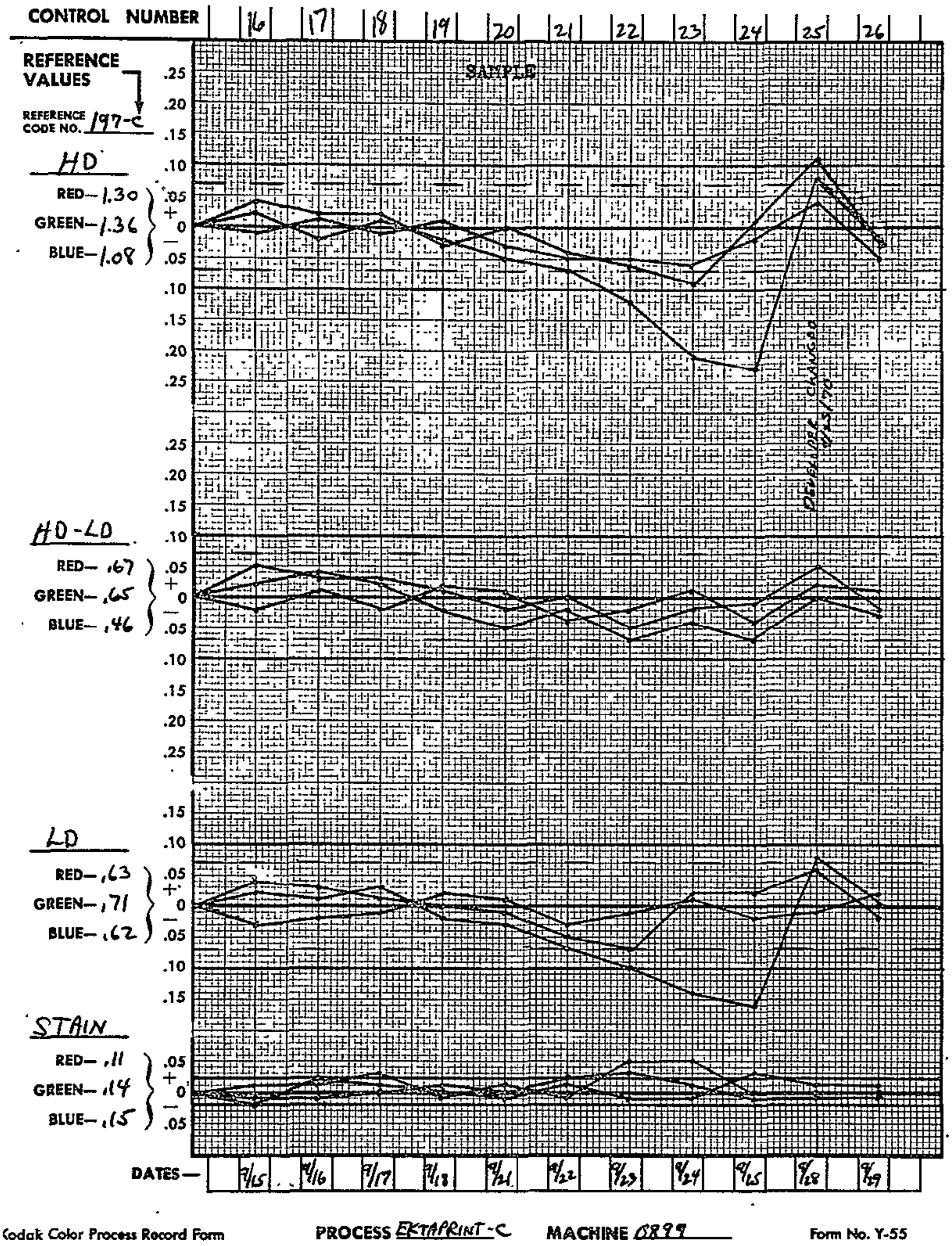

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Figure 5-8 Example of Sensitometrics Control Graph for Color Paper Processing Control (Derived from a Color Reflection Densitometer)

through the red, green and blue filter of the color densitometer. The readings obtained from the reference strip are permanently recorded and the readings from each control strip processed are compared to it. The differences in the values of these readings are recorded and plotted on the Color Process Record Form. With each line on the Record Form representing one unit (.01) of density, the amount the control strip differs from the reference strip can be recorded to form a continuous graphic record of the process. The values read through the red filter are plotted using a red pencil, blue values with a blue pencil and green values with a green pencil.

The densitometric readings of all correctly processed control strips should, theoretically, be identical to the reference and plot on the zero (0) index line. In practice, however, neither the process nor the densitometric measurements are perfect. The nearer the reading from the control strips plot to the index line, the more uniform the process is and will thus yield a consistently high-quality product.

Suggested beginning parameters for color film control should be indicated by a red line on the Color Film Process Record (Figure 5-7). Limits of ± .05 for D-Min, .08 for Low Density (LD) and ± .07 for High Density Minus Low Density (HD-LD). Every effort should be made to improve and reduce these limits within the framework of operating procedures and production.

If any of the plotted points fall outside the upper or lower tolerance limits, the process should be considered out of control and corrective action should be taken to bring the process into better control.

Systematic monitoring of the process in this manner will provide a continuous graphic record, will indicate the degree of process uniformity, the direction of any shifts from standard and a basis for locating and correcting any problems in the process.

The High Density Minus Low Density plots are a measure of the red, green and blue contrast of the film. Once the contrast of the negative has been adversely affected, it cannot be corrected in the printing operation. Deviation from normal of contrast in the negative will affect the color saturation and tone reproduction (highlights and shadows) in the prints.

The Low Density plot primarily indicates process activity and will ultimately affect printing time and color reproduction.

Deviations from standard processing conditions which will affect printing time, color reproduction and shadow renditions will be revealed in the D-Min plot which indicates the colored coupler densities, the development fog and the stain level produced by the process.

Monitoring of color paper processing is done in much the same way as with film, the recommended parameters being $\pm$ .07 for the High Density Minus Low Density value and for the Low Density value and $\pm$ .02 the control limit for the stain patch (Figure 5-8).

A preexposed, undeveloped paper control strip is run through the print processor prior to each processing run and as often as needed to establish and maintain constant quality control. After processing, the strip is measured with a calibrated color reflection densitometer. Readings will be obtained from the High Density cyan patch through the red filter, the High Density magenta patch through the green filter and the High Density yellow patch through the blue filter. The same readings will be made on the Low Density and stain patches. These readings are entered on the Process Record Form and plotted. If the control strip plot is within the prescribed tolerance limits of the reference strip, the paper is introduced to the processing line. If the plot should indicate that the process is out of control, corrective action is taken immediately and another control strip processed and plotted.

A judicious evaluation of all color products made in support of the ERTS mission must be made to insure that the high standards of quality have been met. All color prints must be properly color balanced, as well as ideally displayed and free from streaks or stains.

5.2.4.4 Multiband Color Compositry*

All control standards for black and white and color photographic processing will be applicable to this production. It must be realized that the techniques introduced to this system will offer unlimited exposure combinations, i.e., filtration and light intensity. The types of display that will be possible will be at the discretion of the experimenter. After determination by these users, exposure control and filtration must be controlled by various settings and filter numbers.

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*See Appendix C for a discussion of a conceptual compositing system.

6. PERSONNEL ESTIMATES FOR MANNING ERTS DATA SYSTEM

Table 6-1 presents an estimate of the number and general categories of personnel required to operate the ERTS photographic data system. The estimates are based on the expected data rates defined in Section 3. The time lines presented in Section 3 were predicated on: (1) the "on-line" operations - 7 days a week, 8 hours a day; and (2) the "off-line" operations, i.e., data classification,* montage, User Service, etc., 5 days a week, 8 hours a day basis. These considerations are reflected in the personnel listed in Table 6-1. Personnel cost estimates can be readily obtained by assigning representative pay scales to the identified categories.

6.1 Experience and Training Requirements

The background and training requirements for the personnel listed in Table 6-1 are widely varied. The following discussion will attempt to briefly describe the pertinent requirements.

6.1.1 Initial Processing and Data Evaluation

Accounting and Sorting

The work to be performed in this function is largely clerical in nature and dependable high-school graduates will be suitable.

Calibration, Data Collection, Annotation, etc.

The work of the IPA group requires a number of skills. The group supervisor should be an experienced technical college graduate at the Master's level. He should have some skills in image interpretation, image processing and an awareness of electronic sensing and display procedures. Two of the IPA personnel, namely, the Calibration Monitor and the Data Package Integrity Supervisor, should be experienced technical college graduates at the Bachelor's level or equivalent. Their experience should parallel the IPA supervisor's experience; i.e., having skills in image interpretation, image processing and electronic sensing and display. If optical data-processing techniques are to be used for noise analyses, an individual trained in application of those techniques will be required.

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*An extremely limited type of classification is assumed in the time line estimates.

TABLE 6-1

PERSONNEL REQUIREMENTS FOR ERTS DATA CENTER

(U. S. Coverage Only)

Major Activity	Personnel Category / Functional Work Area	Senior Management	Senior Technical S	Senior Technical T	Technical Senior S	Technical Senior T	Technical Junior	Clerk Senior	Clerk Junior	Secretary	Key Punch Typist	Total Functional Area
Major Activity	Functional Work Area											4
IPA	Accounting & Sorting						2	1	1			
	Data Evaluation		1*	1		1	1	1	2			7*
	Systems Analysis		1	1			1					3***
	Master Photographic Processing Laboratory		1		1		1					3***
PPL	Photographic Production Laboratory		1	1	8	1	2	1	1		1	15**
USA	Montage/Mosaic Activity						1		1			2***
	Data Collation			1	2			1	1		1	6**
	Data Classification Center		4			1	1	2			1	9***
	User Services Activities		1		1	1				1	1	5***
Management	Data Center Management	1	1							1	2	6***
	TOTAL (category)	1	10	4	12	4	9	6	6	2	6	60

TOTAL DATA CENTER STAFF (U. S. Coverage) = 60

*7 days per week, 8 hours per day

**Partial staffing, 7 days per week, 8 hours per day

***5 days per week, 8 hours per day

Estimates based on U. S. coverage only, approximately 12 minutes of sensor operation per day. If one additional hour of taped data is taken, the estimates shown should be multiplied by a factor between 3 and 5.

Key: S = Scientific
T = Technician

The remainder of the IPA functions can be accomplished by persons who may have had some technical background from military schools or non-degree technical schools.

Systems Analysis

Two persons with extensive backgrounds in the scientific aspects of remote sensing will be assigned to the Systems Analysis group. These persons should have Bachelor's degrees and 8 to 10 years of experience in remote-sensing programs. Their scientific backgrounds could have emphasized any discipline in which remote sensing is applied. They should be selected for their interest in the technology of remote sensing.

6.1.2 Photographic Systems

The photographic processing functions of the ERTS Data Center should be under the direction of an experienced precision photographic laboratory supervisor. The background of the supervisor should include at least 15 years of experience in all types of photographic processing in color and black and white. A five-year background of experience and/or education in photographic optics and chemistry is essential. The photographic laboratory supervisor should have a color specialist supervising the color processing.

The background of the color specialist should parallel the laboratory supervisor. The eight color and black and white photographic technicians should have at least five years of experience and one year's training in photographic theory. The junior laboratory helpers should have one or two years of experience and some training in photographic processing.

Montage and Data Collation activity can be staffed with dependable high-school graduates. Experience in an environment such as the Nimbus/ATS Data Center would be very useful. The data-collation supervisor should be capable of handling a small printing shop. This will probably mean 10 years of experience in managing the job coordination aspects of a technical publications organization, since one task to be performed in data collation will be to assemble catalogs for subsequent delivery to a reproduction facility for printing and periodic binding into volumes.

6.1.3 User Service Activities

Data Classification Center

The Data Classification Center will employ the majority of earth scientists in the ERTS Data Center. Four of the scientists should have a Master's Degree and at least five years of experience in remote sensing as it relates to the Geology, Hydrology, Agriculture/Forestry and Geography disciplines. Another individual should have a Bachelor's degree in Meteorology or Oceanography, with four to five years' experience in atmospheric remote sensing.

The reason for having qualified earth scientists is rather obvious if resource classification is to be done; however, many more than five will be required if extensive classification is undertaken. The reason, in the case of the limited classification, is to provide a qualified interface between the data-processing function and the potential users. When users come to the Center, these scientist assist them in obtaining the information best suited for their individual needs.

The other personnel in the data classification area should be required to have experience in splicing film, preparing film logs, etc. This work can be performed by non-degree technical school graduates. A key-punch operator will be required at least parttime.

User Service Center

The User Service Center has essentially two main activities: (1) To provide the facilities, tools and assistance needed by users, either those who come in person or who write; and (2) to monitor and format, if required, cloud-cover predictions received from ESSA or other sources. The scientific assistance will probably be provided from the Data Classification Center. However, at least one person with an education at the Bachelor's level in some earth science discipline and experience in remote sensing applications should be available to provide general assistance and relay questions to the appropriate individuals. A librarian with experience in a small, scientific library can serve as librarian and receptionist. A meteorologist with a Bachelor's degree and experience in interpretation of satellite photography will be required for monitoring and formatting of cloud-cover predictions for sensor programming. A key-punch operator will be required parttime for logging user requests, etc.

6.1.4 Data Center Management

The Data Center Manager should have a background which includes, in addition to skills in personnel management, a comprehension of each of the activities to be performed. A Master's degree in some field of remote sensing with 10 years of recent experience in managing remote-sensing data programs would be a minimum requirement.

In addition to the Data Center Manager, there should be a Senior Scientist to oversee all the scientific operations. The Senior Scientist should have a specialty in remote sensing with emphasis on the technology of sensing. A Master's degree with 10 years of experience should be an acceptable background.

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7. PLAN FOR IMPLEMENTATION OF DATA CENTER

The establishment of a major facility like the ERTS Data Center requires extensive advanced planning in order that a functional system will be available at launch. Figure 7-1 presents an ERTS Data Center implementation plan for defining six activities and the time frames within which they must be completed prior to ERTS launch. The six activities include:

1) Specification and ordering of long-lead time equipment.
2) Development of detailed operating plans.
3) Specification of and ordering of operating materials (expendables).
4) Installation of major equipment.
5) Recruiting and hiring of operating staff.
6) Training of operating staff and publication of prelaunch guides to users.

7.1 Specification and Ordering of Long-Lead Equipment Items

Some of the equipment required for the ERTS Data Center operation, e.g., the proposed color composite projection system, the precision photographic enlarger, some film processors, etc., are long-lead items and thus should be ordered as soon as practicable.

7.2 Development of Detailed Operating Plans

Development of detailed operating procedures for the ERTS Data Center should be a continuing effort. The procedures outlined in this report can provide a baseline, but the operational plans will require iterative analyses through the entire planning period.

7.3 Specification and Ordering of Operating Materials

In order to achieve a uniform quality in photographic products, it is usually necessary to use a single-emulsion production run. The same type of emulsion cannot be exactly duplicated from one batch to the next. (Color is more affected by emulsion changes than is black and white) and observation of changes in tone

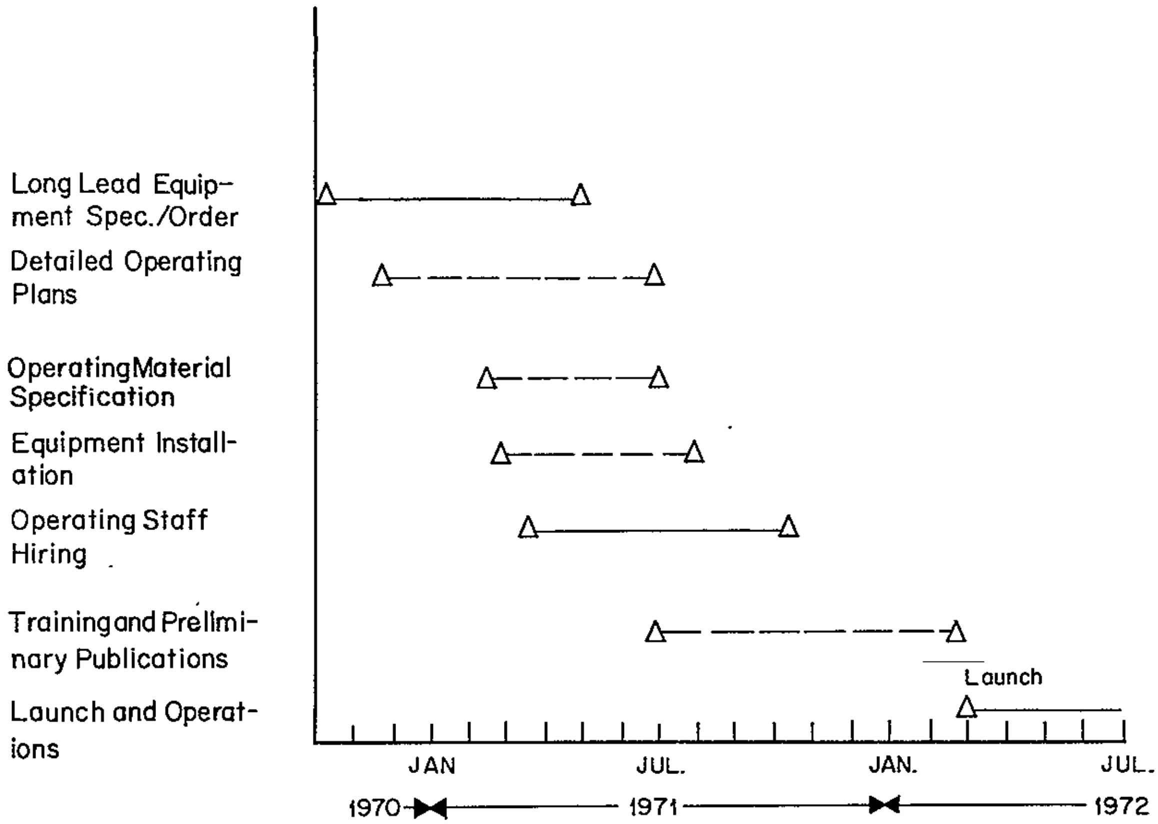

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Figure 7-1 ERTS Data Center Implementation Plan

or color in a given area is important to the ERTS program. A 90-day supply of a single emulsion batch (approximately five separate observations of the same geographic locality) seems acceptable from a storage and manufacturing viewpoint. The total amounts of film to be used during the planned one-year operation of ERTS-A is large (see Section 3 for estimated footage), hence the 90-day production run of a single emulsion batch will be large. The manufacturers capable of handling such large orders usually require fairly extensive lead times. Similarly, requirements can be stated for chemicals, photographic paper, etc. The period from first quarter 1971 to mid-1971 is proposed for the completion of the ordering processes.

7.4 Installation of Major Equipment

The major equipment required for the ERTS photographic data management program involves fairly extensive installation and checkout. Each major equipment element must be fully checked out and certified as operable prior to the launch, since extensive training and total system exercising will be required during the period immediately prior to the scheduled launch. It is estimated that the period from first quarter 1971 until last quarter 1971 be utilized for major installation and invidual element checkout.

7.5 Recruiting and Hiring of Operating Staff

In this activity, it is assumed that the lead personnel will already be employed and heavily involved in the planning efforts. The operating staff will, therefore, include only those personnel who are required for the actual operations of each Data Center element. A logical hiring order should provide for early procurement of highly skilled equipment operating personnel and, later, procurement of those whose activities require less detailed skills. A six-month period for the recruiting and hiring efforts has been outlined beginning in mid 1971.

7.6 Training of Operating Staff and Publication of Prelaunch Guides to Users

Experience gained during the operation of NADUC indicates that the newly hired personnel should be placed in a training program immediately upon reporting for work. The training program will utilize a classroom and in-service format that would provide each individual with an understanding of the complete system,

its goals and requirements, as well as with an understanding of the details of his particular task.

Some of the newly hired personnel may assist in preparation of an ERTS Data System User's Guide. This document should be prepared with the most up-to-date information possible on the ERTS system. It should, however, be published and distributed to designated users before launch.

We have outlined the period from mid 1971 until the beginning of the system check preceding launch and operation of the satellite for these training and publication activities.

8. RECOMMENDATIONS

8.1 Photographic Facility Plan

The facility plans described in Section 4 of this report define two separate but closely interrelated photographic facilities. The Master Photographic Processing Laboratory (MPPL) provides initial high-quality processing for the master film, the Photographic Production Laboratory (PPL) provides all the photographic production work. The MPPL must be kept in close proximity to the electronic film display activities in the NDPF. The PPL can be placed in any appropriate location, preferably outside of the planned NDPF of Building 23. The separation of the MPPL and PPL activities is most important since the quality of initial production cannot be maintained if it is mixed with the many and varied processes required in the PPL.

We strongly recommend a separate PPL to assure minimum constraints on physical growth of the facility in response to rising requirements from ERTS data users. However, if this plan is to be considered, some efforts must be directed to identify potential sites for the PPL. New building starts for GSFC require the approval of Congress. Offsite locations are rapidly being acquired for other uses. A listing of suitable locations, estimates of construction time lines and cost could provide a basis for further planning.

8.2 Color Composite Production

As pointed out in Section 5.2.4 and Appendix C, the production of color composites for ERTS will be a significant part of the total photographic effort. The conceptual Projection Color Composite Production System, featuring recovery directly on film, will greatly expedite production and maximize quality.

If the proposed concept is of further interest in the ERTS program, some additional study should be directed to establishing reasonably clear pricing and, following that, to definition of the interest in making the capability a part of the ERTS NDPF.

8.3 Data Quality and Content Classification and Abstract Preparation

A suggested concept for data classification and content evaluation is discussed in Section 4.3.3. The current plan is for rather minimal evaluation of the

cloud cover and assessment of other obscurations to vision. Some limited topical content discussion may be included. A detailed concept for content classification is presented as Appendix A of Merritt et al. (1969).

Some early tests should be given to the possibilities and requirements for application of the detailed classification concept since any decision to implement the concept may require a fairly extensive reevaluation of personnel estimates. In a related situation, abstracts are now expected to be prepared by the users. If it became necessary to prepare the abstracts in the NDPF, trained personnel will be required. There is a close relationship between the content classification efforts and the abstract efforts since they will both require the same type of personnel. It is possible that the same people who would do the classification could also do the abstraction

A thorough review of the abstraction procedure is required prior to the time that hiring begins for Data Center senior personnel.

8.4 Implementation

Implementation of the ERTS Data Center plan will require a continuing effort. Some of the most important considerations are:

1) Development of detailed operating plans. This will be a continuing effort until all elements of the ERTS system have been defined.

2) Specification of detailed overall facility plan. This study has emphasized the photographic facility.

3) Some elements of the equipment for the ERTS Data Center are long-lead items. Definitive specifications should be developed as soon as possible so that orders can be placed.

4) Training programs for the ERTS Data Center personnel will need to be prepared well in advance of the actual hiring of personnel. Work should begin on the required training materials as each element of the Center's operation becomes more clearly defined.

9. REFERENCES

Merritt, E. S., W. C. Ahlin, L. Goldshlak, J. J. O. Palgen, R. R. Sabatini and J. Sissala, 1969: Management, Processing and Dissemination of Sensory Data for the Earth Resources Technology Satellite, Technical Report No. 11, Contract NAS 5-10343, Allied Research Associates, Inc.

Greaves, J. R. and T. R. Markham, 1966: Nimbus Photogrammetric Attitude System Program Documentation, Technical Report No. 2, Contract NAS 5-10114, Allied Research Associates, Inc.

Sabatini, R. R. and G. Rabchevsky, 1970: Use of Ground-Truth Measurements to Monitor ERTS Sensor Calibration, Technical Report No. 16, Vol. II, Contract NAS 5-10343, Allied Research Associates, Inc.

Sabatini, R. R. and J. E. Sissala, 1968: Project Nero (Nimbus Earth Resources Observations)", Technical Report No. 7, Contract No. NAS 5-10343, Allied Research Associates, In. (Vol. II currently in preparation)

Palgen, J. J. O., 1970: Application of Optical Processing for Improving ERTS Data, Technical Report No. 16, Vol. I, Contract NAS 5-10343, Allied Research Associates, Inc.

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APPENDIX A

CATALOG FORMAT AND PREPARATION

Two approaches to sensory data dissemination using catalogs are presented below. Either approach appears feasible but the proposed catalog detailed in A. 2 below is recommended.

A. 1 Separate Catalogs for Abstraction, Classification and Montages

A. 1. 1 Classification and Abstraction Catalogs

The main purpose of these catalogs is to inform users what data are available and to describe their quality. The data come primarily from the log sheet information prepared in the Quality Assurance and Standards area and in the Data Classification Center. Additional necessary items include an ascending node listing of all orbits with imagery and a U. S. or world map with a transparent subpoint track overlay to locate the imagery.

Perhaps the best method for organization of the orbital data would be to group together all orbits which pass over an assigned longitudinal zone on the earth. This organizational procedure would simplify most data searches by users since they generally are looking for all imagery of a certain area. The ascending node listing could also be organized in the same fashion. If the catalog were bound in loose-leaf format and published monthly, the latest month's information could be integrated with that from previous volumes.

If the first ERTS satellite concentrated on U. S. coverage only, the following scheme might be useful for a combined classification and "abstraction" catalog.

Each orbit of data over the United States would contain, at most, about 14 data sets (three RBV and four MSS frames per set). The basic information on each data set can probably be presented in 80 units of coded information which could be contained on one punched card. Only 20 lines of computer printout (including heading information) would be required for each orbit of data. The orbital data would, in turn, be organized by longitudinal zones. If one page were allotted for each data orbit, three-fourths of the page would be blank. Into this part of the page would go any abstraction or descriptive information relating to that orbit. This data would be supplied by all classes of users as well as by the

classification analysts. Users might find this abstract information as useful as the classification information since it would identify significant items, and suggest items for further research as well as discuss the image quality and cloud cover. Users could make more intelligent and precise requests for data based on this information. The volume size for such a catalog (of the United States) would not be large. There would be only 40 pages (40 orbits) every 18 days or about 400 pages every six months. Updated and revised information for a specific orbit could easily replace an individual page.

A. 1. 2 Montage Catalog

A. 1. 2. 1 Data Sources

The montages could utilize high-quality 70 mm contact prints. Since the reduced montage will probably lose image quality in the copy process, it is planned to use the imagery from the RBV and MSS which should display maximum feature contrast. In most instances, the maximum contrast features will be found in the green or red channel. An attempt should be made, in photographic processing, to retain and/or enhance the definition of the montage preparation imagery.

A. 1. 2. 2 Size and Scale

Evaluation of the size requirements for preparation of a global montage from 70 mm contact prints indicates that a montaging surface would need to be approximately 25 x 25 ft. The process camera required to copy this large an area would be operated from about 25 ft and would produce a 16" x 20" image. Since a 16" x 20" size reduced from 25 x 25 ft size is approximately a 25 x reduction, the original 70 mm image size would become a 2.5 mm image. This is barely useful even for determining that an image exists at that spot without trying to determine the picture content.

A regional approach to montage preparation has been selected. Table A-1 presents the major world land areas (these areas are outlined on a map shown in Figure A-1*) and the montage size, picture elements and scale for a standard 16" x 20" distribution format. Note that the maximum working montage

*Data for only land areas are expected for the initial ERTS. The areas shown on Figure A-1 and the data outlined in Table A-1 give maximum area sizes to include the required land areas.

TABLE A-1
ERTS MONTAGE AREAS

Montage Area	Montage Size (inches) Latitude and Longitude	Approximate Number of Pictures in Montage	Montage Scale if Longest Dimension Reduced to 16 inches
USA and Central America	42" x 72"	1030	1.16,400,000
Canada	37" x 90"	1050	1:20,500,000
Alaska	30" x 54"	510	1·12,310,000
South America	80" x 60"	1550	1:18,250,000
Africa	90" x 85"	2400	1:20,500,000
Europe	42" x 49"	650	1:11,180,000
Western USSR	47" x 90"	1350	1 20,500,000
Eastern USSR	47" x 90"	1350	1·20,500,000
Australia	55" x 55"	930	1:12,550,000
South Asia	42" x 85"	1130	1·19,400,000

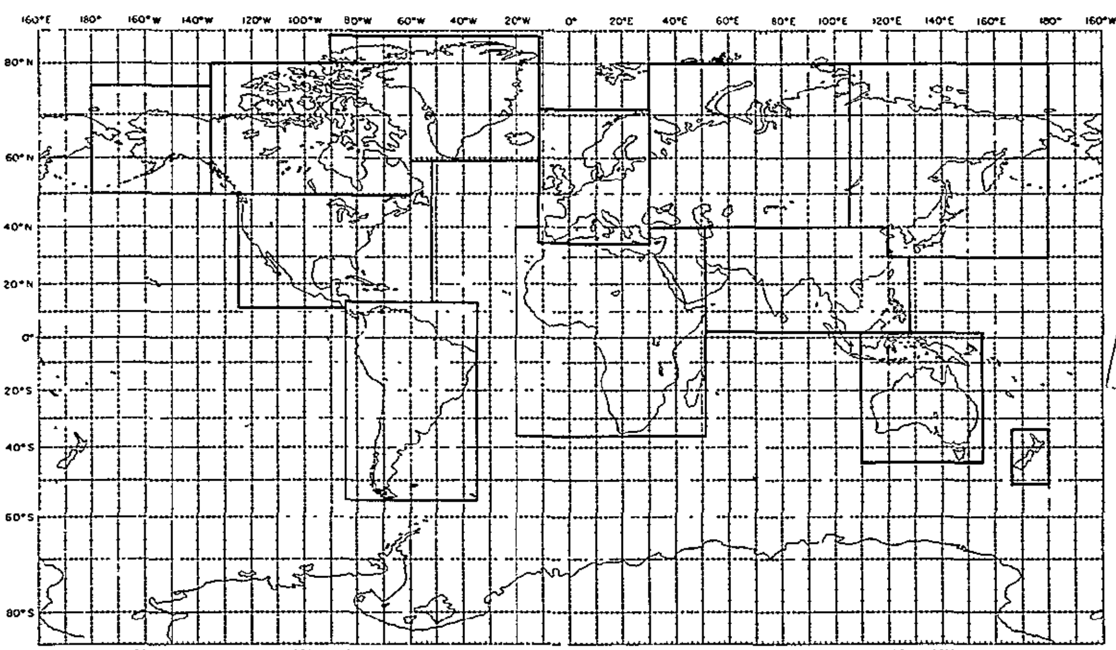

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Figure A-1 Regional Montage Area Coverage

size is 90" x 85" for Africa. This size image will be much more suitable to work with and it provides a reduced 70 mm image size of about 10 mm. Although the regional montages could provide useful information for prospective ERTS data users, we recommend implementation of the alternative approach recommended in Section A. 2.

A. 1. 2. 3 Catalog Format

The montages of the RBV and MSS images could be completed every 18 days over the United States and the pages shipped to the approved users along with three overlay pages. The overlays, prepared on mylar film would contain:

1) The location and identification of each frame making up the montage.

2) The geographic outline of the montaged area, including political boundaries; i. e., state lines, national borders, and perhaps the most significant local boundaries such as counties and even rough approximations of the city limits.

3) An overlay of predicted subpoint tracks for future passes. The format should permit users to select, in advance, their coverage of particular interest.

The overlays would be registered with the montages by appropriately placed marks placed on both the montage and the overlay. We anticipate overlay preparation by computer in advance of the operational requirement, but after launch. The unique transverse mercator projection created by a satellite earth-looking sensor field is not standard. An accurate projection must be prepared from actual, definitive, orbital information.

At the conclusion of one year of ERTS operation the montage pages should be assembled into a bound, printed catalog for general distribution to the user community. If world coverage is obtained, a decision would be required regarding the total number of catalog volumes to be prepared.

3 ⊕

A.2 Recommended Content and Format of an Alternate ERTS Data Catalog

This section defines a recommended ERTS Data Catalog. Included are recommendations for:

1) The organization concept and format for RBV and MSS image displays with correlating coverage maps.
2) A classification information display format for orbit and orbit frame data.
3) Descending node data orbit lists.
4) The organization and procedure for inclusion of user-supplied ERTS abstracts.
5) Data Collection Subsystem platform information format.
6) Special displays of data applications.
7) A continually updated bibliography of ERTS reports and symposia.
8) A listing of ground-truth experiments related to the ERTS program.

A.2.1 Data Zone Concept

The ERTS design requirements specify that successive coverages of an area be identical and that successive days of coverage be contiguous. The ERTS catalog image display format and the data storage and retrieval system should exploit these satellite system requirements. The zone concept accomplishes this.

The United States is divided into twelve zones derived from successive 5^{o} equatorial longitude points. Extensions of lines across the United States from these points, parallel to the ERTS subsatellite track, establish the zone boundaries. Figure A-2 shows the zone coverages over the United States and Table A-2 presents the equatorial longitude points.

In an 18-day period either three or four data orbits would always fall within each zone. These orbit groups would always be displayed together in the Data Catalog with their corresponding zone coverage map (see suggested layout in Figure A-3).

Experience at the Nimbus/ATS Data Center indicates that data requests are largely made on the basis of geographic location. Thus, in the ERTS photographic laboratory, the archival and working master film should be arranged for storage and retrieval utilizing the same geographic zones as used in the catalogs.

TABLE A-2

U. S. DATA ZONE (EQUATORIAL) LONGITUDE LIMITS

ZONE	LONGITUDE LIMITS
1	80 - 84.99W
2	85 - 89.99W
3	90 - 94.99W
4	95 - 99 99W
5	100 - 104.99W
6	105 - 109 99W
7	110 - 114 99W
8	115 - 119.99W
9	120 - 124.99W
10	125 - 129.99W
11	130 - 134.99W
12	135 - 139.99W

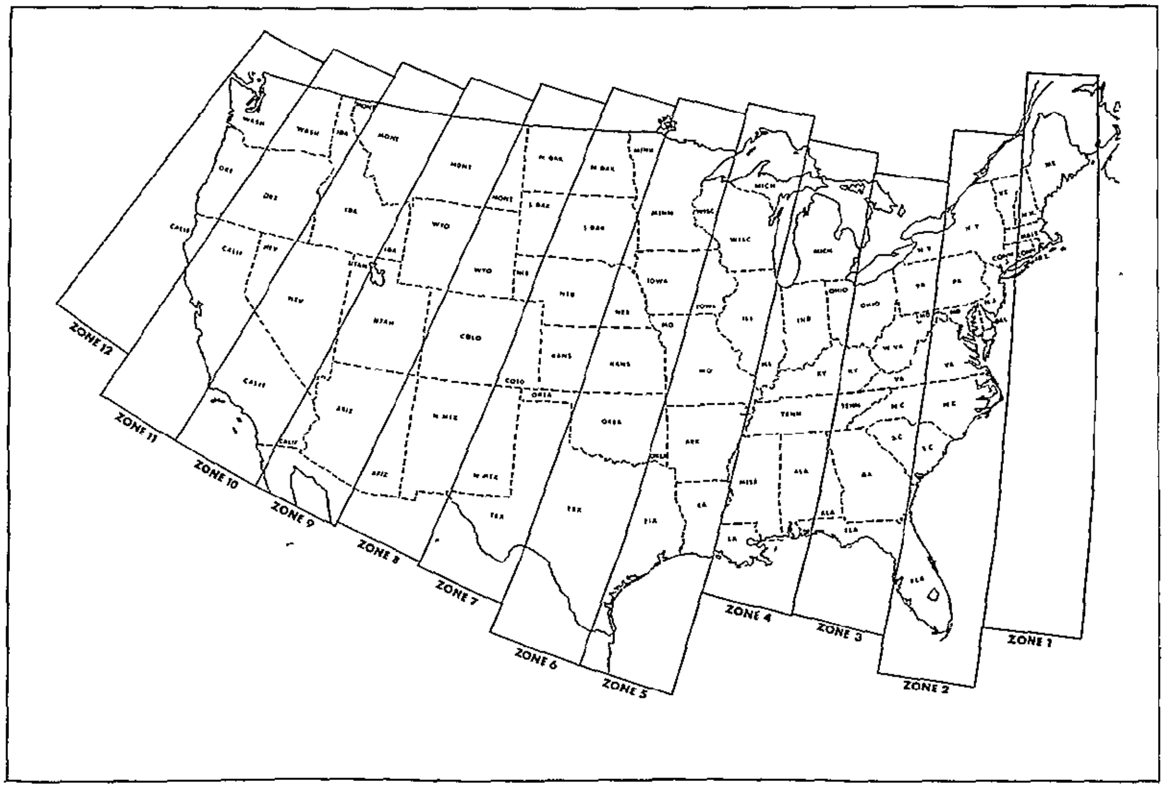

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Figure A-2 U. S. Zone Coverage Map

A.2.2 Zone Data Orbit Image Display

An 11" x 17" catalog page size is recommended so that the data content in the image displays will be discernible. Each page would contain two montaged image displays; one from the RBV system and one from the MSS. Each would display the same three or four orbits of contiguous coverage (representing a zone's coverage) but each would show a different spectral band for optimum frame information. (The RBV could display the 0.58 to 0.68 micrometer band while the MSS could display the 0.8 to 1.1 micrometer band.)

Assuming an 0.75" square frame size, each of the two four-orbit displays would have a maximum size, for U. S. coverage, of 12" x 3". Image scale would be about 1: 10,000,000. Each data orbit would be labeled by orbit and date. Figure A-3 is an example of this display format. Figure A-4 illustrates Apollo IX imagery at the 0.75" size and several other selected sizes.

A.2.3 Annotated Zone Coverage Map

The ERTS image display should include a 1: 10,000,000 zone coverage map with states and major water bodies identified. Each data set location (principal point) and its orbital data set reference number should also be identified on this map. The data set reference numbers adjacent to the principal points allow each data set to be referenced to its data classification information.

Data orbit and date labels on this map should correspond with those of the image display. Figure A-3 contains a zone coverage map example.

A.2.4 Classification Information Display Format

Information will be extracted and recorded for each orbit and each data set within each orbit. Figure 4-10 (of Section 4.3), a suggested classification Log Form presents the recording format for use in the ERTS Data Center. The same format should be used in the data catalog, i.e., one line for orbital information and one line for each data set's information.

Classification information for each orbit should be placed on the page facing its image display. In this way, three or four orbits of classification information would be immediately related to its corresponding image and location map display.

A.2.5 Non-U. S. Coverage Display Format

While current plans suggest that most ERTS data will be recorded over the United States, requirements will probably be generated from time to time for coverage of other areas of the world. These images should be formatted and classified in the same manner as the U. S. coverage; i. e., sequential data frames should be montaged together and displayed with an annotated coverage map on one page with the facing page containing classification information. If the orbital coverage consists of only a few frames, the classification information could be placed on the same page as the imagery.

Data zones, by continent, similar to the U. S. zone system, should be established and used in data displays whenever sufficient coverage is obtained.

Non-U. S. coverage of limited areas should always be included in the U. S. catalog for widest possible data dissemination. In case of extensive non-U. S. coverage separate catalogs may be necessary.

A.2.6 Complete U. S. Montage Display

For each U. S. coverage period (18 days), two complete U. S. montages will be prepared (one RBV and one MSS) and reduced photographically to fit a 17" x 22" format for inclusion as foldouts in each data catalog. Each frame would be about 7/16" square on an 18" x 7" reduced montage display. (See 0.5" frames in Figure A-4 for an example of the data content at this frame size.)

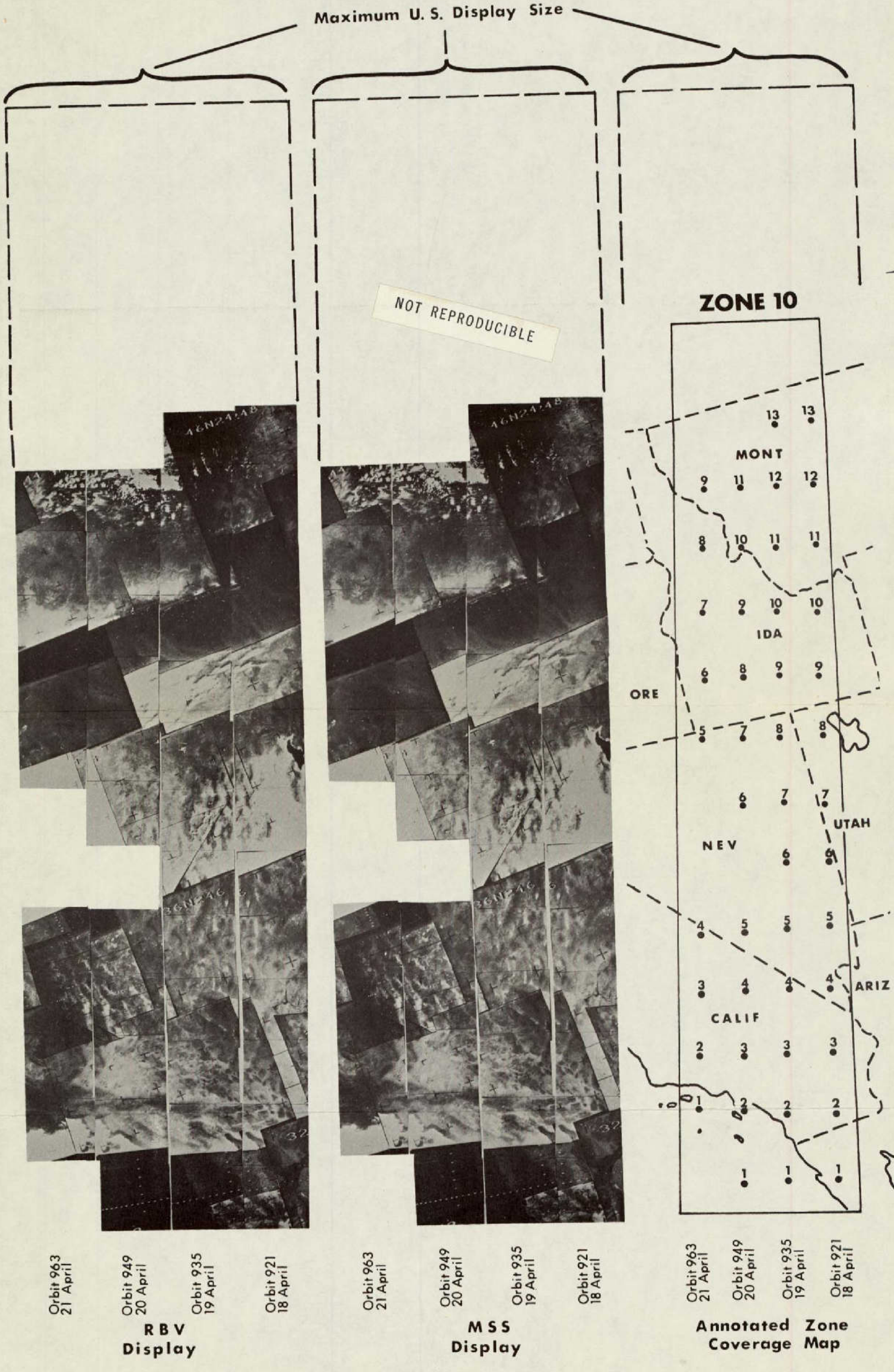
A mylar overlay, to be used on these U. S. montages, should be prepared and included with the <u>first</u> data catalog. The overlay should outline the state and national political boundaries, major cities, rivers, lakes and prominent topographic features seen in the imagery.

The overlay and montage would be registered using appropriately placed marks on both the montage and the overlay. The montage features and the overlay will not have exact correspondence since the montages will present the sidelap (30 percent over the United States) from contiguous orbits.

A.2.7 Data Content Abstracts

It is anticipated that ERTS data users will prepare and submit abstracts of analyzed imagery to the ERTS Data Center for inclusion in a data catalog.

FOLDOUT FRAME 1



FOLDOUT FRAME 2

Figure A-3 Simulated RBV/MSS Image and Annotated Zone Map Display Using Nimbus 1 AVCS Imagery

60 lb Finch Opaque Vellum Finish

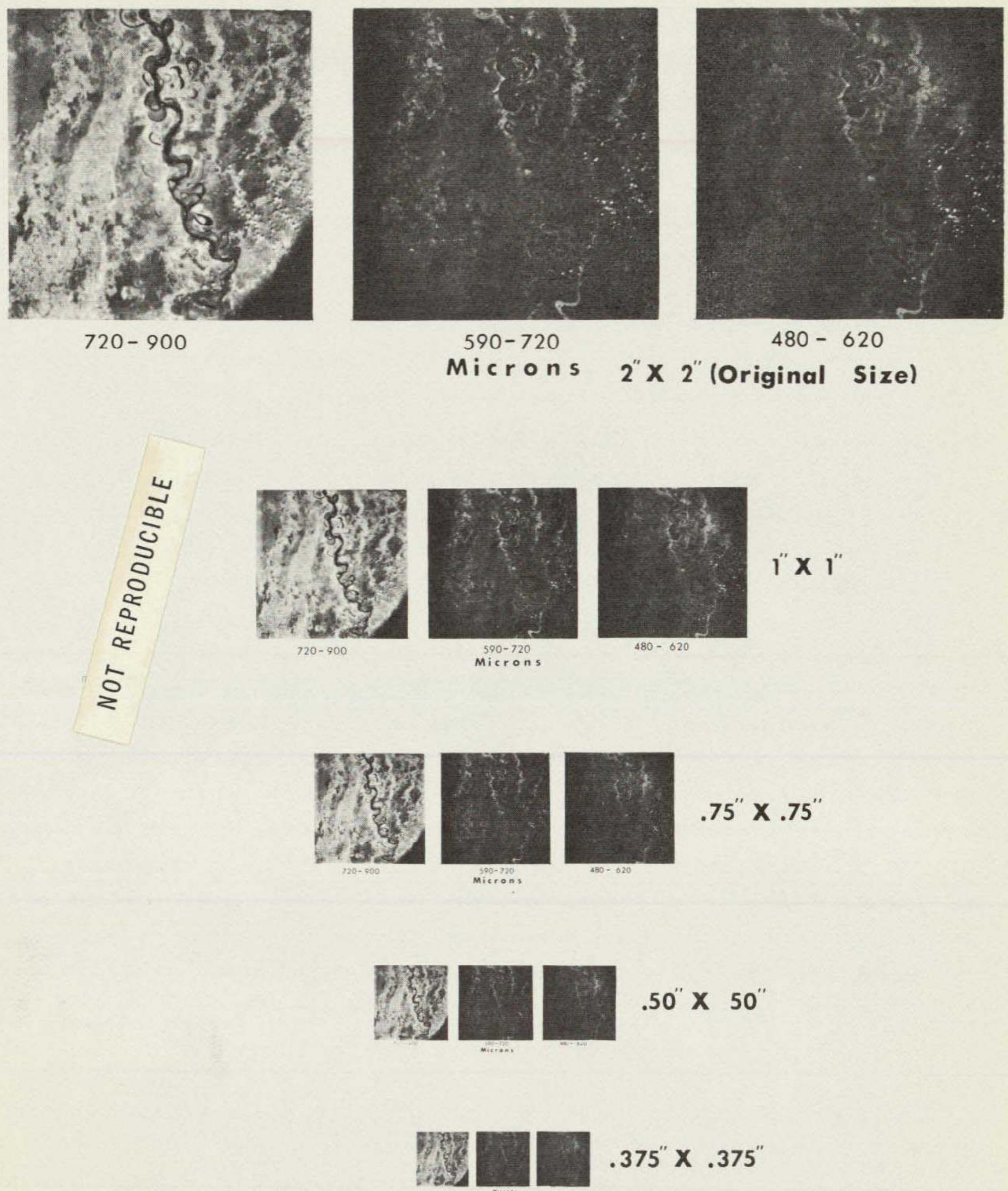


Figure A-4 Apollo IX, 75 x 75 Nautical Mile Imagery at Various Frame Sizes

Normally, these abstracts will correlate with imagery from previously published data catalogs. Therefore, the following system is proposed to mate returned abstracts with their appropriate previously published data:

In each current catalog there will be a section entitled "Past ERTS Abstracts." All abstracts for each previous catalog would be listed together on a separate page or pages and sequenced by zones to correspond with those described for the image and classification displays. Then each catalog user could remove these abstract pages from the current catalog and place them in their proper "past catalog" either in a section entitled "ERTS Abstracts" or with their corresponding image display page.

At the end of some time period after launch, an evaluation could be made to determine if it were worthwhile to publish a separate ERTS Abstract Catalog.

A.2.8 Descending Node Data Orbit Lists

Descending node data orbit lists, if properly formatted, would serve as a quick reference for satellite data coverage utilizing a minimum number of catalog pages. All satellite coverage from launch to some future period could be included in each catalog. Three lists, each organized by sequential equatorial longitude and grouped by zone are recommended.

Since the descending node longitudes do not fall within the U. S. coverage, a supplementary aid included with these lists would be a graph of subsatellite track longitude differences (from an equatorial longitude) at every latitude. To approximate the satellite's location at any latitude one would add or subtract a specified number of degrees of longitude to each descending node in the listings.

A.2.8.1 Current Catalog Period

This list would organize all coverage for the period of the current catalog. Table A-3 is an example of this for an 18-day coverage period.

TABLE A-3

DESCENDING NODE DATA ORBIT LIST FOR CURRENT CATALOG

ZONE	ORBIT	DATE	DESCENDING NODE	COVERAGE
1	724	4 April	80.00W	43-48 N
1	738	5 April	81.44W	43-48 N
1	752	6 April	82.88W	41-50 N
1	766	7 April	84.31W	40-50 N
2	780	8 April	85.75W	24-50 N
2	794	9 April	87.19W	24-50 N
2	808	10 April	88.63W	24-48 N
3	822	11 April	90.07W	27-45 N
3	836	12 April	91.50W	27-45 N
3	850	13 April	92.94W	28-45 N
3	864	14 April	94.38W	28-45 N
4	878	15 April	95.82W	28-48 N
4	892	16 April	97.26W	28-48 N
4	906	17 April	98.69W	28-48 N
5	920	18 April	100.13W	28-50 N
5	934	19 April	101.57W	28-50 N
5	948	20 April	103.01W	25-50 N
5	962	21 April	104.45W	25-50 N
6	725	4 April	105.88W	24-49 N
6	739	5 April	107.32W	25-48 N
6	753	6 April	108.76W	26-49 N
7	767	7 April	110.20W	28-50 N
7	781	8 April	111.64W	28-50 N
7	795	9 April	113.07W	28-50 N
7	809	10 April	114.51W	29-50 N
8	823	11 April	115.95W	30-50 N
8	837	12 April	117.39W	30-50 N
8	851	13 April	118.83W	30-50 N
9	865	14 April	120.26W	31-50 N
9	879	15 April	121.70W	31-50 N
9	893	16 April	123.14W	32-50 N
9	907	17 April	124.58W	32-50 N
10	921	18 April	126.02W	32-50 N
10	935	19 April	127.45W	33-50 N
10	949	20 April	128.89W	33-50 N
11	963	21 April	130.33W	34-50 N
11	726	4 April	131.77W	35-50 N
11	740	5 April	133.21W	36-50 N
11	754	6 April	134.64W	38-50 N
12	708	7 April	136.08W	39-50 N
12	782	8 April	137.52W	40-50 N
12	796	9 April	138.96W	40-50 N

A. 2. 8. 2 Launch to Current Catalog Period

This list would summarize all coverage from launch to the current catalog period. All coverage for each data zone would be listed together as in Table A-4. With each new catalog this listing would add those orbits from the previous catalog.

A. 2. 8. 3 Current Catalog Period to Six Months Hence

This third list would specify the expected U. S. coverage assuming nominal operations. It would be organized similar to Table A-4 of past data coverage. Thus, a user would have a complete coverage history of all data already acquired over specific locations as well as a list for planning purposes of all potential coverage for an extended time into the future.

A. 2. 8. 4 Page Requirements for Descending Node Data Orbit Lists

Page requirements for these lists would be minimal for an 11" x 17" catalog since 40 lines of standard type (one line per orbit) utilize only 5" of space. A listing of an 18-day period with 40 data orbits could easily be shown on one page. A listing for 7 months of past data would require about 500 lines (500 orbits) or about four 11" x 17" pages. A listing for 6 months of future coverage would also require four pages. Thus, over a year's listing of U. S. coverage, however split among the three data orbit lists, would not require more than 9 pages. In fact, by appropriate columnar spacing, this information could be listed on four or five pages.

A. 2. 9 "ERTS Notes" and Special Displays

Data dissemination is a fundamental rationale for the ERTS catalog. The image displays and data classification meet this objective. Two other data sources which should be included are a listing of the various sources of published material and meetings about ERTS, and a special displays section on useful or unusual applications of the ERTS data.

TABLE A-4

DESCENDING NODE DATA ORBIT LIST
FROM LAUNCH TO CURRENT CATALOG PERIOD

ZONE	ORBIT	DATE	DESCENDING NODE	COVERAGE
1	013	10 Feb	80.02W	39–50 N
	027	11 Feb	81.46W	38–50 N
	041	12 Feb	82.90W	40–50 N
	055	13 Feb	84.33W	40–50 N
	250	28 Feb	80.01W	38–50 N
	264	1 Mar	81.45W	38–50 N
	278	2 Mar	82.90W	39–50 N
	292	3 Mar	84.32W	40–50 N
	487	17 Mar	80.01W	37–50 N
	501	18 Mar	81.44W	37–50 N
	515	19 Mar	82.89W	35–50 N
	529	20 Mar	NO DATA	
2	Zone 2 thru 12 listings would be similar to zone 1 listings and would contain all orbits from launch to the listings in the current catalog.			

A. 2. 9. 1 "ERTS Notes"

Since the ERTS catalog will be published regularly it should provide a review on how the data are being used. Published articles, contract reports, notices of ERTS meetings and symposia and planned ERTS experiments by Government, universities and private organizations should be listed if known far enough in advance of publication. Each researcher in the field needs to know who is doing or has done what. This kind of information may help reduce duplicate research and provide a useful source of ERTS information.

A. 2. 9. 2 Special ERTS Displays

This section should present special pictorial displays of data applications. As new uses of the data are documented, personnel with the User's Services Center of the ERTS Data Center will prepare displays to demonstrate these applications. These displays might use all seven of the sensor bands, a digitized display, a color composite, a time series of a particular location or special coverage of an unusual application. The display in Figure A-5 is an example from the Nimbus satellite imagery of the class display envisioned.

In summary, these two sections would serve as reference sources for new data users and as an update on current data applications for the "old hands".

A. 2. 10 Summary of Satellite Operations

The experimenters who helped design each system and personnel in the ERTS Data Center will be monitoring system performances against established criteria. One section of the catalog should be used by these people to review sensor operations and problems. Calibration checks of ERTS image gray-scale densities vs radiance (voltage) relationships at selected ground-truth sites would be one item for inclusion in this section. This catalog procedure has been used effectively in the Nimbus Data Catalogs.

A. 2. 11 Data Request Information and Procedure

Every catalog should contain a one- or two-page section listing the kind of data that are available (positives, negatives, prints, film and print sizes, color composite possibilities, digitized data, etc.) and how these data should be requested.

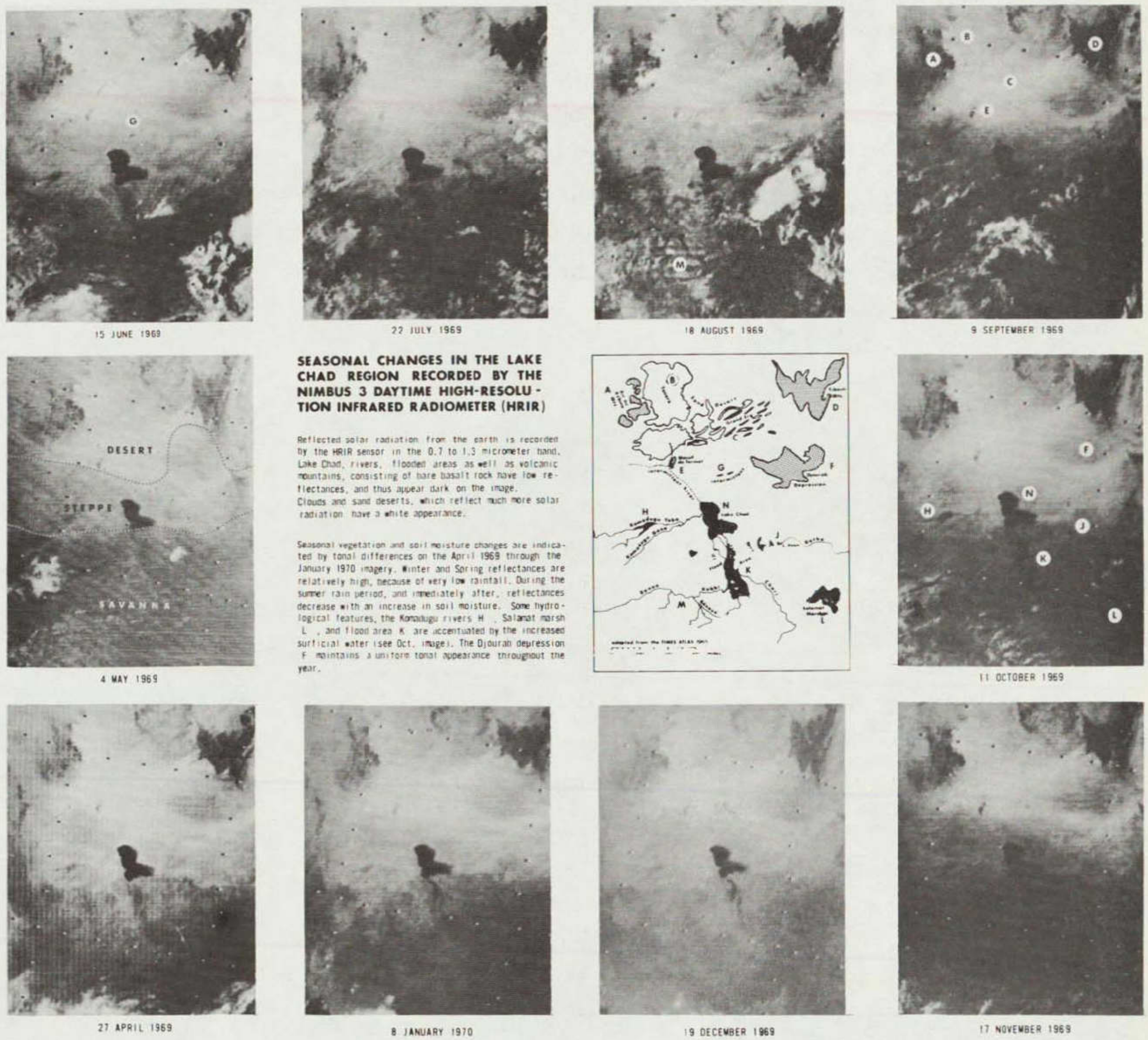


Figure A-5 A "Special Display" Using Nimbus 3 Imagery as an Example

A data request form should be printed with each catalog to assist in the efficient processing of each request.

A.2.12 Data Collection Subsystem (DCS) Information Format

The ERTS DCS will receive, store and retransmit to the ERTS Data Center, information gathered from a variety of ground and water based sensing platforms. Each data catalog should contain a format for the listing of the following DCS information for each platform:

1) Location
2) Major function
3) Normally sensed information
4) Normal sampling routine (every hour, twice daily, etc.)
5) Dates for which data are available
6) Correlating ERTS imagery of DCS platform area (listed by date, data orbit and frame or picture time)
7) Address of agency responsible for compilation of actual data from each platform.

This format would not list the routine accumulation of recorded platform parameters. Interested users would be instructed to write to the responsible agency for these specific data.

A.2.13 Supplementary Ground-Truth Experiments

Special ERTS ground-truth experiments using aircraft underflights and ground surveys will be conducted from time to time by various groups. The nature of these experiments, i.e., sensor used, where, when, and kind of data collected, correlating ERTS imagery, preliminary results, and sources for further specific experiment information, should be reported in this section.

A.3 Data Catalog Publication Parameters

A.3.1 Data Catalog Publication Schedules

The logical publication period is every 18 days or some multiple thereof, since this is the time required to complete coverage of the United States (or any other large area). Although the first ERTS will be an experimental research tool, the data will very quickly be requested for practical and beneficial applications. Additionally, the passage of time reduces the data value to many applications. Therefore, it is recommended that 18-day Data Catalogs be published.

Since the data catalog will be continually assembled during each 18-day coverage period, it should only take an additional two weeks to complete this assembly. Two additional weeks will be required for final typing and formatting. Catalog printing may require another month after this. Thus, shipment of these catalogs should occur two months after the end of an 18-day data catalog coverage period.

A.3.2 Quantity of Data Catalogs per Publication Period

The Nimbus project at GSFC currently prints 1200 copies of each Nimbus Data Catalog. Approximately 750 are routinely distributed to the various user centers with the remaining used to satisfy the daily requests from new user sources. Routine ERTS distribution of 1000 copies (with 500 additional copies for ongoing user requests) will satisfy the user groups shown in Table A-5.

A.3.3 Page Requirements for an 18-Day Coverage Period Data Catalog

The minimum to maximum number of pages for most of the catalogs can be well estimated. However, some sections such as "Non-U. S. Coverage" and "Past ERTS Abstracts" could have large variations in page requirements. Page estimates for an 18-day coverage period data catalog and the order in which each section should appear are shown in Table A-6.

A.3.4 Reproduction Quality and Catalog Cost

High quality paper and printing control standards are required for catalog reproduction to insure that the data content of the original image display is faith-

TABLE A-5

ERTS CATALOG DISTRIBUTION LIST

APPROXIMATE NUMBER DISTRIBUTED	USER GROUP
200	All U.S. government agencies engaged in ERTS data analyses or in the ERTS project.
100	Selected state agencies which may have ERTS data uses.
300	All universities and colleges with remote sensing or active earth science programs.
25	Independent Science Centers
100	Private industries and business
50	Individuals with special needs
200	Foreign ERTS Users

TABLE A-6

SUMMARY OF DATA CATALOG PAGE REQUIREMENTS

TYPE OF INFORMATION	NUMBER OF 11" x 17" PAGES	
	MIN.	MAX.
Title Page	1	1
Foreword	1	1
Table of Contents	1	1
Summary of Satellite Operations	2	6
"ERTS Notes"	1	2
Special Displays	1	6
Data Request Information and Procedure	1	2
Descending Node Data Orbit Lists	5	9
Data Collection Subsystem (25 platforms per page)	4	10
U.S. Classification Information	12	12
U.S. Image Displays	12	12
Non-U.S. Classification Information	0	12
Non-U.S. Image Displays	0	12
Complete U.S. Montage (17" x 22" foldout)	2	2
Past ERTS Abstracts	1	12
TOTAL	44	100

fully reproduced. Various catalog paper stocks are shown in Figures A-3, A-6 and A-7 and A-4, A-8 and A-9. Examination of these samples indicates that an enamel-base paper (see Figure A-7) provides the best results.

Reproduction cost quotations for an ERTS catalog were requested from three printing companies in the Boston, Massachusetts, area. Each was asked for cost quotations for 1500 catalogs printed on 11" x 17" enamel-base matte-finish stock and spiral bound on the 17" side. Two catalog page requirements were specified; one a 44-page catalog with 15 half-tone pages; the other a 100-page catalog with 32 half-tone pages. (See Table A-7 for the source of these page requirements.)

The following is a tabulation of these quotations.

TABLE A-7

ERTS CATALOG REPRODUCTION COST ESTIMATES
(1500 copies)

Company	44-Page Catalog	100-Page Catalog
A	$1250	$2130
B	$2090	$4090
C	$3520	$8900
AVERAGE	$2287	$5400

While the price ranges are large, a reasonable estimate of catalog costs is possible.

A.4 Summary

Eighteen-day Data Catalogs should be compiled and delivered to the users about two months after the end of a catalog period. Fifteen-hundred copies of each catalog should be reproduced with 1000 being routine distributed and 500 retained for ongoing user catalog requests. Catalog page size should be 11" x 17" with high-quality enamel-base paper stock and a matte finish used for best reproduction of the data content of the photographic displays. Average catalog cost estimates are $2300 for a 44-page catalog and $5400 for a 100-page catalog.

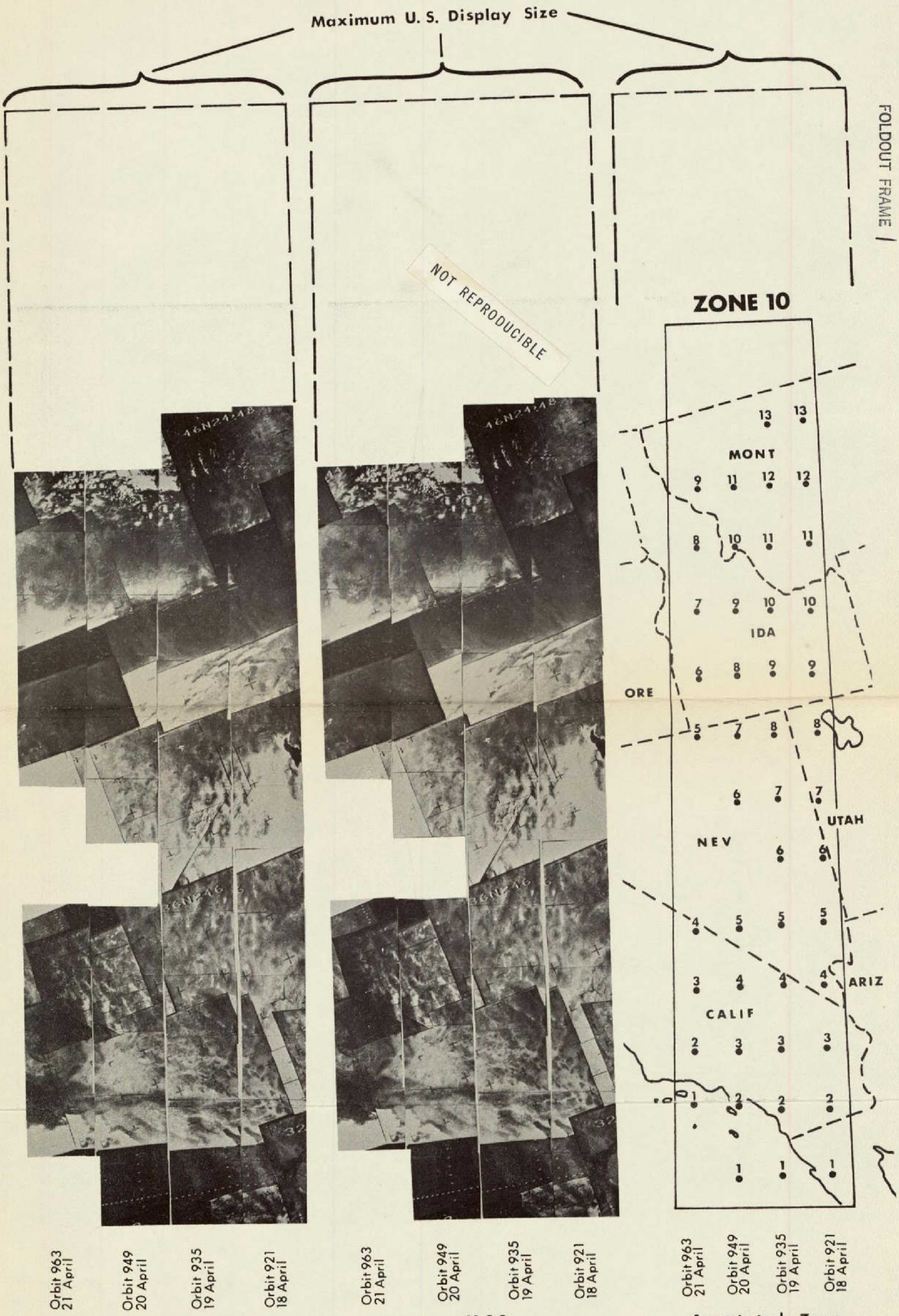


Figure A-6 Simulated RBV/MSS Image and Annotated Zone Map Display Using Nimbus 1 AVCS Imagery

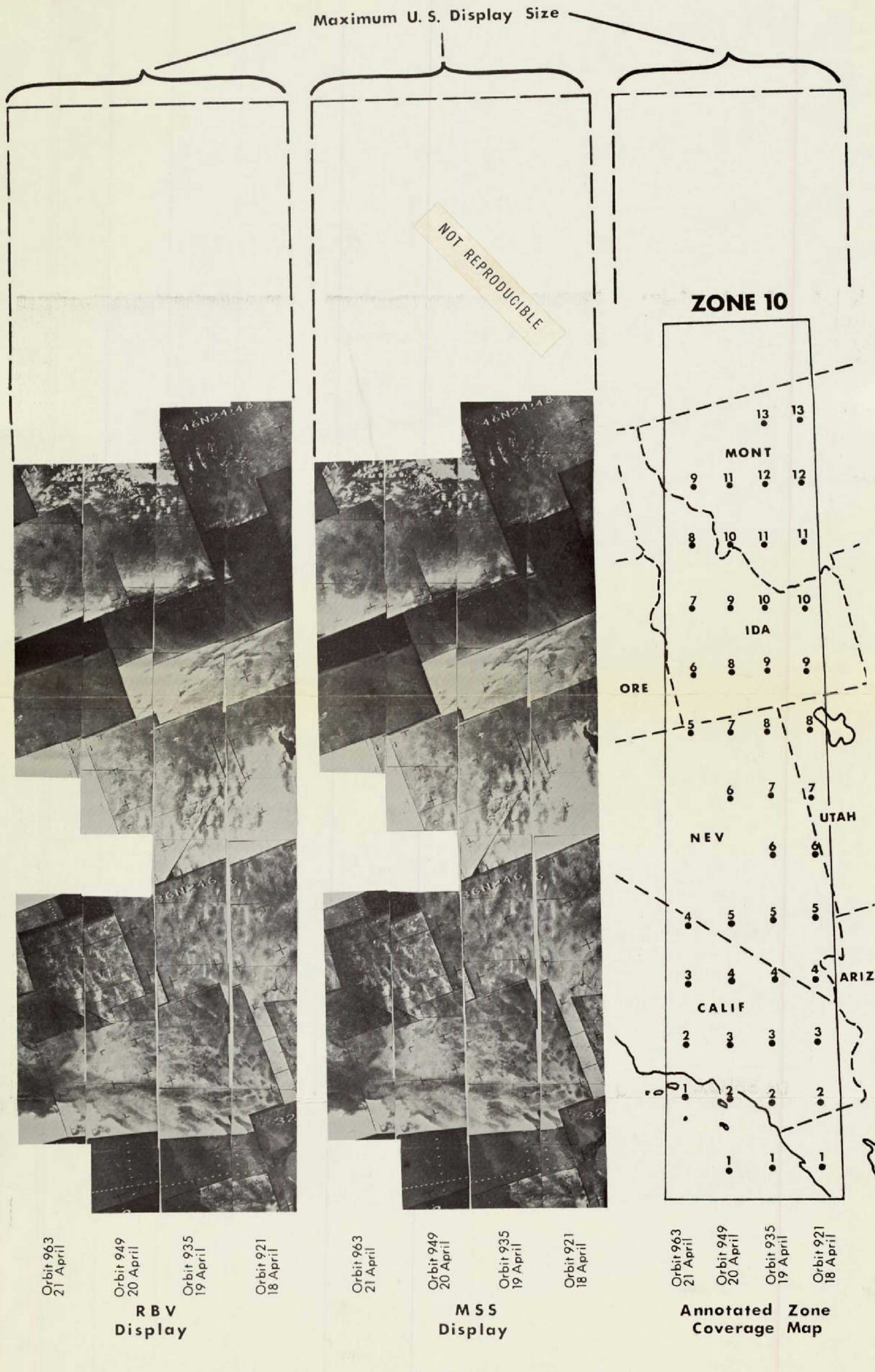


Figure A-7 Simulated RBV/MSS Image and Annotated Zone Map Display Using Nimbus 1 AVCS Imagery

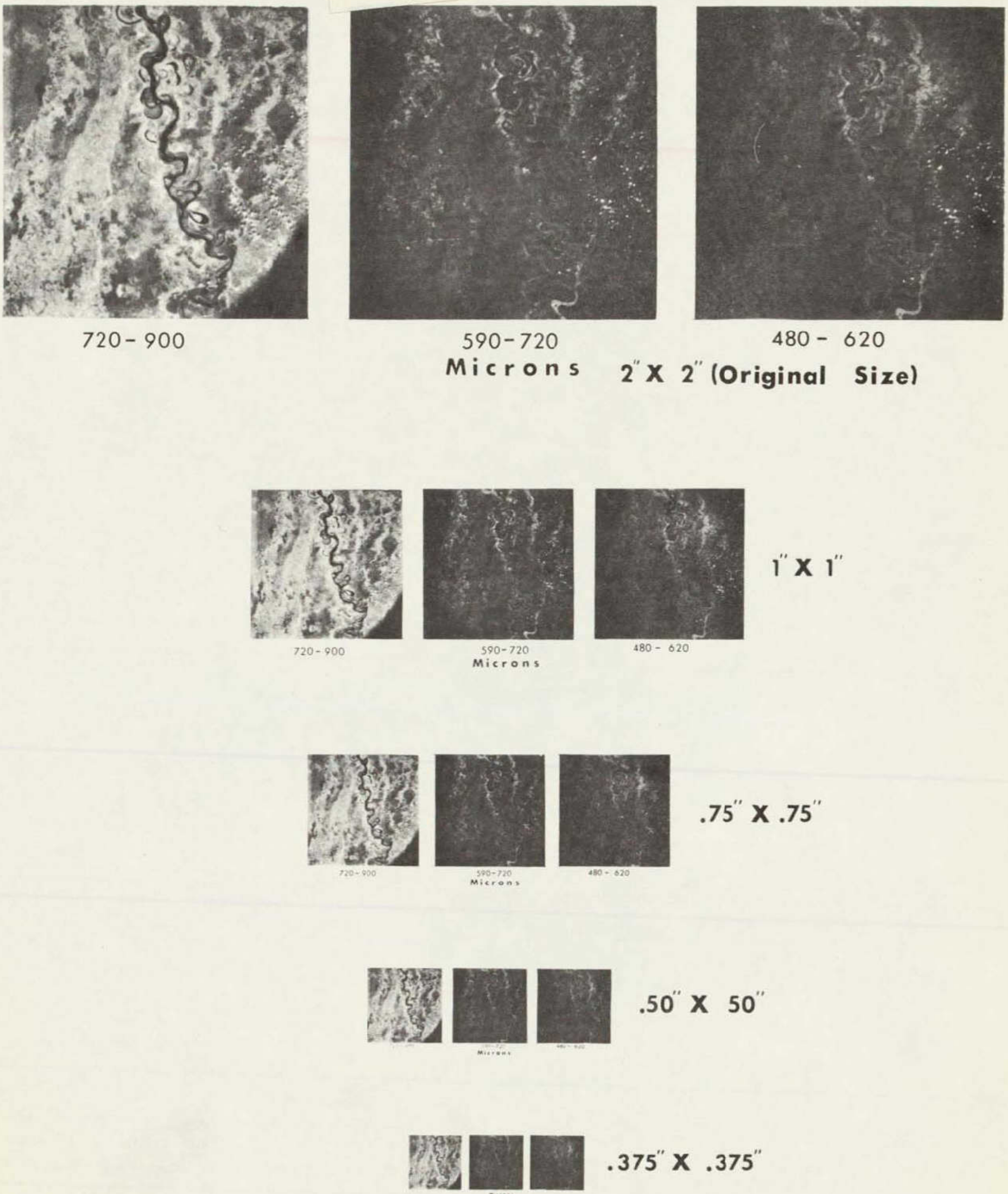


Figure A-8 Apollo IX, 75 x 75 Nautical Mile Imagery at Various Frame Sizes

60 lb Recopake Vellum Finish

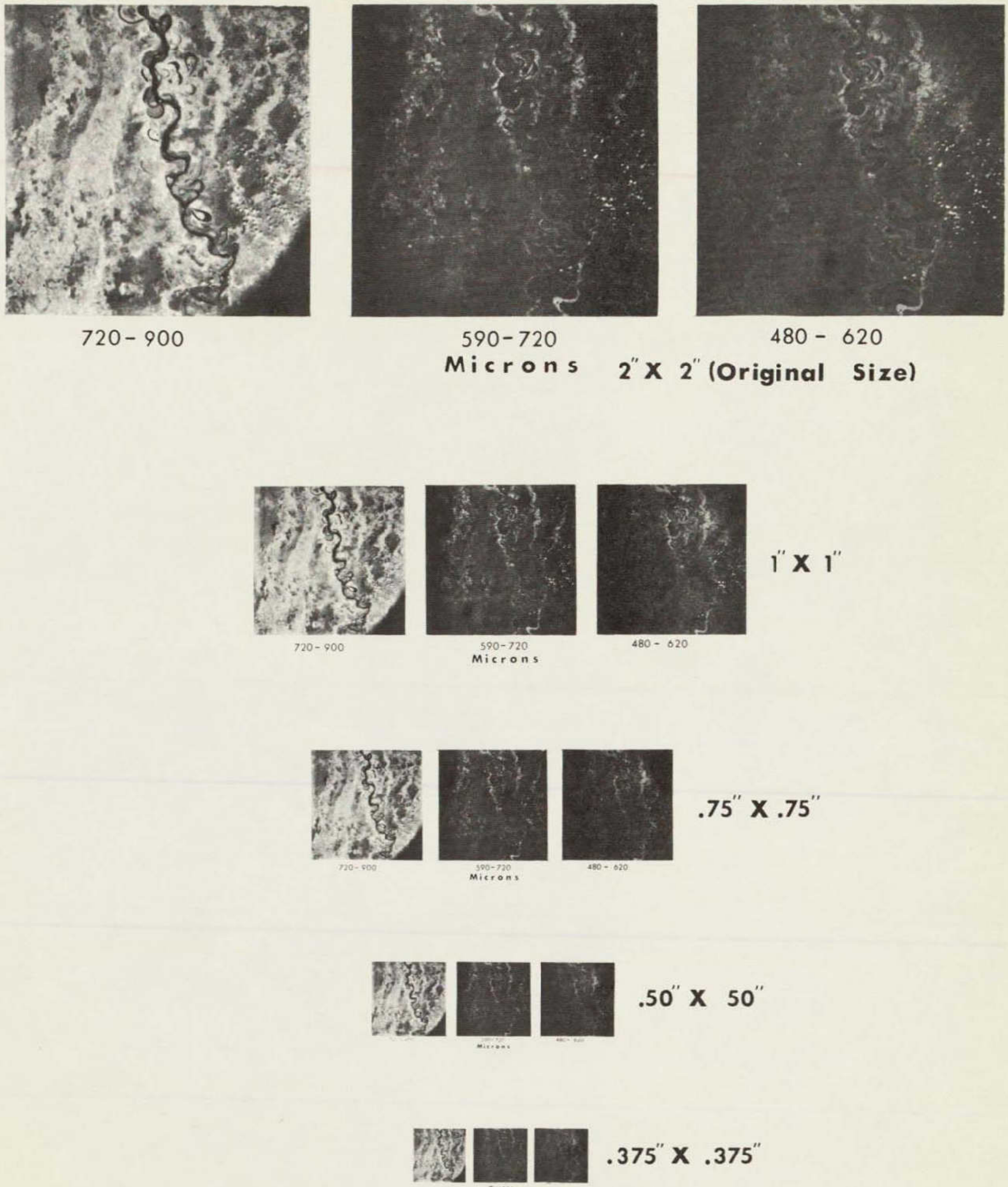


Figure A-9 Apollo IX, 75 x 75 Nautical Mile Imagery at Various Frame Sizes

70 lb Meade Moistrite Matte Finish

APPENDIX B

MANUAL ANNOTATION OF FILM RECORD

B.1 Introduction

In the Return Beam Vidicon (RBV) and Multispectral Scanner Systems, record annotations will be defined, placed on the imagery tapes, and displayed on the photographic products in the NDPF. If subsequent quality assurance reviews not errors in the annotation, two alternative means to initiate the required changes are possible. One approach would be to send the entire record back for reprocessing. It is believed this approach would be inefficient in that it will introduce an increased load on the prime processing activities. The alternate, and recommended approach would be to provide a means whereby the quality assurance activities could manually revise the annotation. Manual annotation changes would permit the quality checking and photographic reproduction cycle to continue while a new revised tape and imagery are prepared on a deferred basis. The following sections of this brief technical note describe the various means for manual film annotation and suggest a recommended procedure.

B.2 Annotation Considerations

It is probable that 70 mm film size will be utilized in the ERTS system. Other widths (5" or 9.5") are also considered. The required annotation should be exposed on the film during the initial display processing below or above the imagery utilizing the provisions incorporated in the system to provide ample interframe spacing. Adequate spacing between frames will reduce film splicing and provide space to make annotation corrections and additions when necessary.

B.2.1 Systems for Annotation

Annotation systems and methods to be considered are:

1) <u>Mechanical</u>

   a) Delaware Portable Film Titler
   b) Varitype-Pressure Sensitive Tape
   c) Prestype

2) Manual

a) Rapidograph

b) Rubber or Metallic Stamp

B.2.1.1 Mechanical

The Delaware Portable Film Titler, Model II

The Delaware Portable Film Titler, Model II (see Figure B-2) is a completely self-contained unit which incorporates heat and pressure to transfer opaque pigment from a special titling tape to the film surface. Standard lead type can be set into the titling block to form a 60 character label in three lines. The titling head also contains a numbering block which can be set for repeat numbering or to advance sequentially in units of one or two. Titling can be accomplished on the edge of the film or in the interframe spacing, requiring a clear area of 1/2" height for a full three-line annotation. The Delaware titler will handle 70 mm through 9.5" film widths in lengths up to 500 ft (900 ft thin base). Operating in white light on 115 volts AC, it is capable of producing up to two labels per minute.

The Delaware titler is available through Eastman Kodak Company, Rochester, New York, on a build-to-order basis only. Single unit, seven-month budgetary delivery price is $23,000. Larger quantities decrease the cost sharply, (i.e., if added on to an order of 14 which are currently being built for the U. S. Air Force, the price would be $7200). The special opaque pigment tape, available in black or white is $3.25 per roll and will print approximately 600 titles.

Some of the advantages to be considered with this method are:

- Neatness
- Nonsmear or smudging of finished product
- Uniform appearance
- Good alignment with image
- One-man operation
- Speed (only if similar label is repeated)

Disadvantages, which must also be taken into account, include:

- High-cost for original equipment and supplies
- Very difficult to remove the label once it has been affixed

Varitype or Pressure Sensitive Tape (Mylar)

Figure B-1 provides a sampling of the maximum and minimum annotation that could be expected from ERTS.

Concern over the possible effusion of the adhesive applied to the tape when pressed to the film base was mentioned. Varied pressure tests proved this to be nonexistent.

Repetitive data can be preprinted on the Mylar, requiring the use of the Varityper to provide insertion of addional and changing alphanumeric data.

The Varitype/Mylar combination as it is now used in the NADUC has been time-tested and proven to be highly satisfactory for annotation.

Prestype

This system employs a transparent material with varied sets of alphanumeric digits printed on one side. The lettered side is placed directly on the film and transferred to its surface by exerting pressure with a stylus. Some of the advantages noted in this method were:

- Inexpensive
- Correction ease

Some of the disadvantages noted were:

- Time: 55 seconds to 4 minutes per label
- Type would dissolve in water, preventing rewash of negative material if required
- Type would flake, resulting in illegible annotation and depositing of residue that would appear in further reproduction

B.2.1.2 Manual

A Rapidograph pen with manufacturer's recommended ink was ordered and received. Evaluation of this device was performed at the Seabrook Facility; i.e., drying time, permanence and uniformity. Dry capability was rated good, permanence and durability excellent, digit uniformity proved to be unsatisfactory. A Leroy Lettering set in combination with the pen was used to provide improved digit spacing and uniformity but the increased time requirement made this method unacceptable.

An evaluation was made using a rubber hand stamp with two ink types. This method did not prove to be acceptable.

B.3 Conclusions

The tests conducted in this brief study suggest that the Varitype/Pressure Sensitive Mylar Tape approach currently used in the NADUC is satisfactory. The more expensive Delaware system of Eastman Kodak is probably the best system but the consideration of cost, again, points to the currently successful Varitype system.

maximum

annotation

SAT BAND ORBIT DAY TIME
1 1 201 239 162137
SUBLAT SUBLONG ALT SUN HEAD
37.4N 105.7W 925 72 231

SAT BAND ORBIT DAY TIME
01 1 201 239 162137
SUB.LAT SUB.LONG ALT SUN HEAD
37.4N 105.7W 925 72 231

minimum

annotation

BAND ORBIT DAY TIME
1 201 239 162137

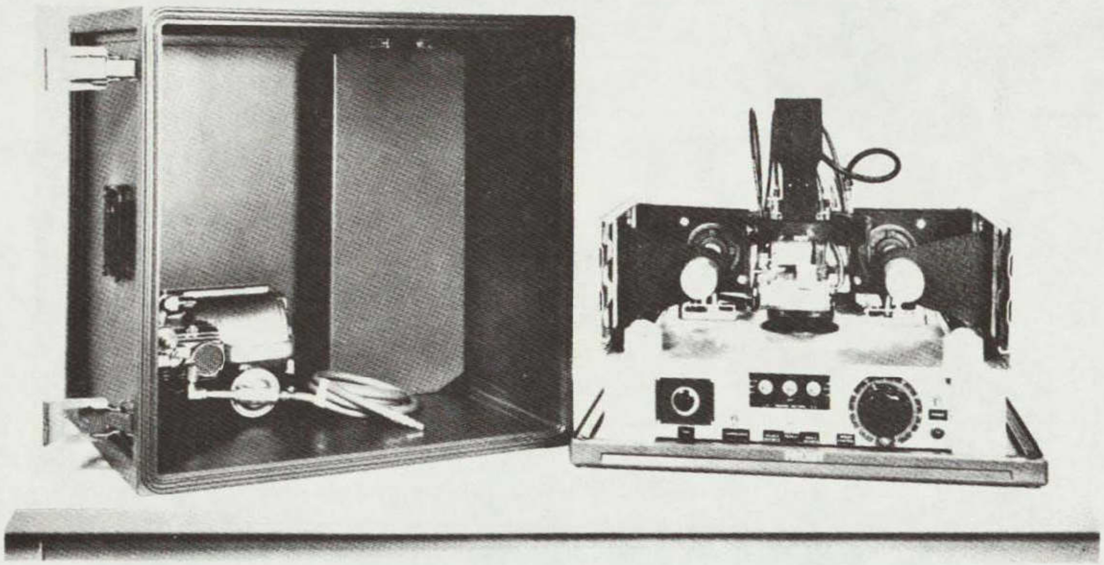
BAND ORBIT DAY TIME
1 201 239 162137

7710

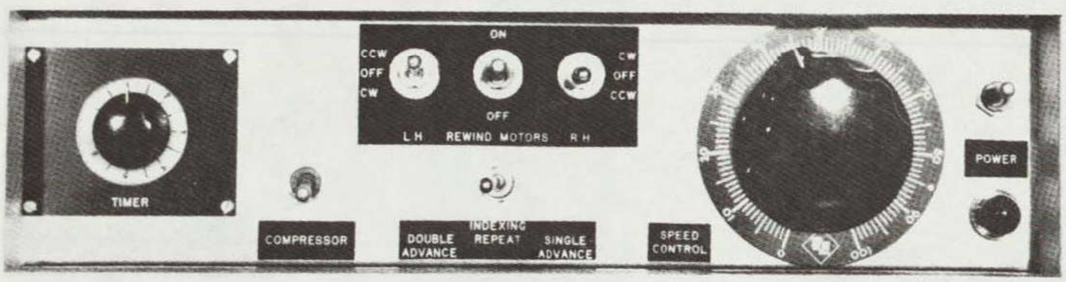
Figure B-2 Sample of Maximum and Minimum Annotation Proposed for ERTS Imagery

DELAWARE Portable Film Titler, Model II

No. 310-001



DELAWARE Portable Film Titler, Model II with rewinds folded in for storage (right) and carrying case (left), showing stowed air compressor and box containing fly-away spare parts and titling accessories.



Control Panel

GROUND HANDLING EQUIPMENT FOR RECONNAISSANCE AERIAL PHOTOGRAPHY

Figure B-2 Delaware Portable Film Titler, Model II

DELAWARE Portable Film Titler, Model II

No. 310-001

DESCRIPTION

The DELAWARE PORTABLE FILM TITLER, MODEL II is a compact, desk-top unit designed for use in limited spaces. Containing its own compressor, the Model II may be quickly set up when needed and requires only electrical service for operation. A sturdy carrying case provides protection during transportation and storage.

The pneumatic titling head and motorized film transport form an efficient system capable of titling large quantities of film with a minimum of machine maintenance. Titling is accomplished by using heat and pressure to transfer opaque pigment from a special titling tape to the surface of the processed film. The air-operated titling head prints a four-digit number plus a block of titling information along the film's edge or, by rotating the head up to 100 degrees in either direction, in the spaces between the frames.

Fixed data which repeats from frame to frame is set in a removable type holder fitted with an insulated handle to facilitate its removal from the type block. The type holder will accommodate up to 44 10-point or 60 6-point characters of standard lead type. The counter may be set for repeat numbering or to advance sequentially in units of one or two.

The motorized transport system accommodates MS 26565 Aerial Film Spools in film widths from 70mm to 9.5 inches and lengths to 500 feet for standard base film. The rewind units are adjustable laterally to provide proper film alignment and fold inward for storage. Winding speed is continuously variable from creep to slew in either direction. Large snubbing grips allow the operator to position the film accurately and easily.

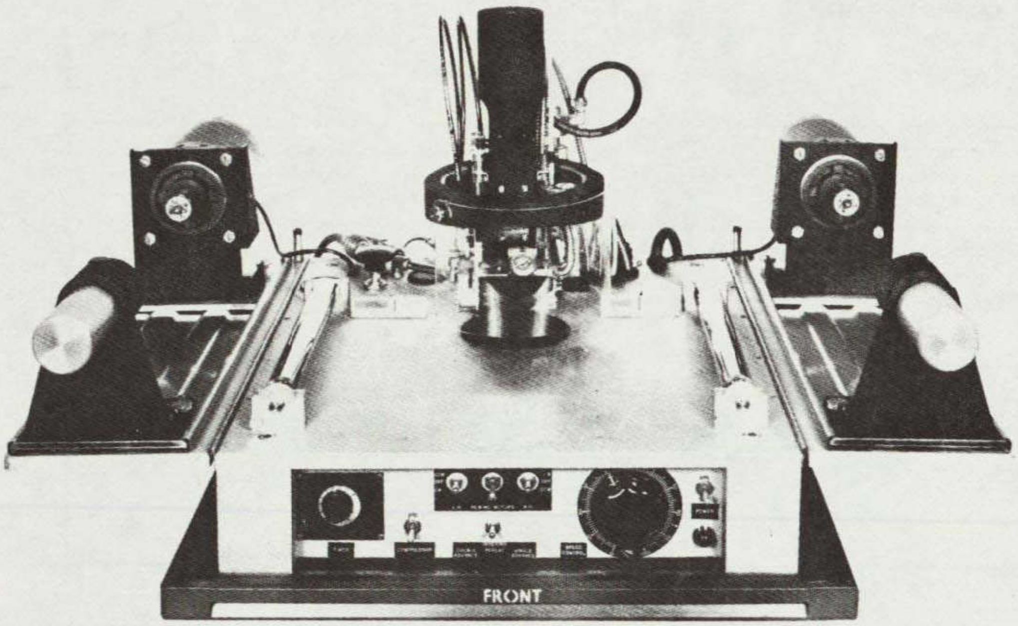
Figure B-2 Cont'd

Purpose

The DELAWARE PORTABLE FILM TITLER, MODEL II is a compact, self-contained titling unit used to apply identifying alphanumeric information along the border or within the interframe spacing of processed aerial film. Widths from 70mm to 9.5 inches can be titled in lengths up to 500 feet for standard base film.

DELAWARE
Portable Film Titler
Model II
No. 310-001

FSN 6740-941-8808



FEATURES

The DELAWARE II titler, is versatile and is designed for mobility, efficiency, and dependability. Compact and self-contained, it can be readily moved and quickly set up for operation wherever 115 volt ac service is available. The motorized film transport speeds titling of large quantities of film and reduces operator fatigue. Easily changed type holders and an auxiliary preheater allow fast changing of title information. Although the titler is compact and lightweight, its sturdy construction assures extended, dependable operation.

GROUND HANDLING EQUIPMENT FOR RECONNAISSANCE AERIAL PHOTOGRAPHY

Figure B-2 Cont'd

DELAWARE Portable Film Titler, Model II

No. 310-001

SPECIFICATIONS		
Material Handled	Processed Roll Film.	
Spindle Capacity **Widths** **Lengths**	 70mm to 9.5 inches on MS 26565 Aerial Film Spools. 500 feet of standard base. 900 feet of thin base.	
Operating Speed	20 titles per minute maximum.	
Power Requirements	115 volts ac, 60 Hz, Single Phase, 15 Amperes.	
Operating Area Illumination	White Light.	
Weight **Titler Unit** **Carrying Case**	 250 pounds. 35 pounds.	
Dimensions	**Open for Operation**	**Carrying Case**
Height	19¼"	21"
Width	36½"	22"
Depth	25"	25"

GROUND HANDLING EQUIPMENT FOR RECONNAISSANCE AERIAL PHOTOGRAPHY

Figure B-2 Cont'd

APPENDIX C

ERTS COLOR COMPOSITE PREPARATION RECOMMENDATION FOR A PRODUCTION SYSTEM

C.1 Introduction

The value of multiband spectral-color photography for Earth Resource Survey has been repeatedly demonstrated with photographs taken from aircraft and spacecraft. The Earth Resources Technology Satellite (ERTS) will provide two multiband sensor systems, i. e., Return Beam Vidicon (RBV) and Multispectral Scanner (MSS). Substantial use can be made of the multiband imagery through sequential or comparative interpretation of each of the three or four images which comprise the multispectral image set. However, it appears from experience of various investigators that a more productive analysis can be made if the multiband imagery is presented as a combined color composite.

While the general methods for production of composite imagery are well known, production photographic systems for color composites are not available.

The following brief discussions will, (a) present the results of some experiments in defining color composites which are potentially useful to various types of users; and (b) describe some conceptual ideas on a production system for color composites.

C.2 Background of Study

The ERTS A and B satellites will carry multiband sensors covering the wavelengths outlined in Table C-1. The RBV bands in the green, red, and near-infrared, approximate the spectral response of Kodak Ektachrome Infrared Type SO-180 film. The MSS essentially duplicates the same bands and adds a fourth band just beyond the photographic infrared (0.8 to 1.1 μm). The selected wavelengths provide excellent determination of natural phenomena. Table C-2 from Colwell et al (1970), presents a list of types of natural phenomena as they relate to detection capabilities of the green, red, and infrared bands.

TABLE C-1

SPECTRAL INTERVALS FROM ERTS RBV AND MSS SENSOR CHANNELS

(in micrometers)

Sensor Channel		Spectral Bands	
RBV	Channel 1	0.475 - 0.575	Green
RBV	Channel 2	0.580 - 0.680	Red
RBV	Channel 3	0.690 - 0.830	Near infrared
MSS	Channel 1	0.5 - 0.6	Green
MSS	Channel 2	0.6 - 0.7	Red
MSS	Channel 3	0.7 - 0.8	Near infrared
MSS	Channel 4	0.8 - 1.1	Infrared

TABLE C-2

OPTIMUM WAVELENGTHS FOR PHOTOGRAPHING NATURAL PHENOMENA

Photograph Identification	Optimum Wavelength Band			
	Blue*	Green	Red	Infrared
Presence or absence of vegetation			X	X
Differentiation of conifers from broad-leaf vegetation				X
Identification of individual plant species		X	X	X
Detection of earliest evidence of loss of vigor in vegetation				X
Identification of agent that causes loss of vigor		X	X	
Determination of the exact course of a meandering stream channel				X
Acquisition of maximum underwater detail (varies with turbidity)		X	X	
Determination of maximum detail in shaded areas on low-altitude photographs only	X			
Identification of geologic formations	X	X	X	X
Differentiation of urban area components		X	X	X

*No earth-orbital sensing in the blue band is contemplated because of excessive scattering of short wavelengths by atmospheric haze particles.

C.3 Color Compositry

All approaches to color compositry use additive optical procedures. Procedures for (1) direct viewing and (2) "hard copy" production are outlined below.

1. If the user's goal is to view a color composite image, the multiband images can be projected through various color filters onto a screen. The color composite results from two, three or four images registered on the screen. An infinite variety of composites can be derived by changing the filters and varying the light intensity. Copies of the color images can be photographed directly from the screen.

2. If the user's goal is high-quality film or prints, the composite is prepared by sequential exposures of the bands through appropriate filters directly to photographic material. In this procedure, registration of each frame is difficult unless adequate registration marks are included on the frame. The time for this procedure can approximate 10 to 15 minutes.

The ERTS PPL is expected to produce about 3000 color composite per month, assuming 15 users receive only one copy of 20% of the total data received for U. S. coverage. Obviously, there is a need for a production system that can produce large numbers of color composites to meet user needs.

A manual color composite test was conducted by Allied Research Associates, Inc. , in the NADUC (Seabrook) Photographic Facility, utilizing a single color enlarger as the optical projection system, and registering the projected imagery on a horizontal easel. The test utilized imagery taken during the Apollo IX SO-65 experiment identified as:

Frame	Camera	Film	Filter
AS9-26B-3701 B	B	Panchromatic	58B
AS9-26C-3701 C	C	Infrared	89B
AS9-26D-3701 D	D	Panchromatic	25A

Figure C-1 presents the three frames in black and white. Figure C-2 shows the result of the experimental compositry using manual registration and color filters to obtain various color composites. (Print No. 12 is a normal composite. A brief discussion of the potential usefulness of the various types of color composites to natural phenomena detection is presented in Section 5.) The method used to obtain the information shown on Figure C-2 is described below.

PRINT NO. 1

PRINT EXPOSURE METHOD	TAKING CAMERA	FILM	FILTER
NORMAL	B	PANCHROMATIC	WRATTEN 58 B

PRINT NO. 2

PRINT EXPOSURE METHOD	TAKING CAMERA	FILM	FILTER
NORMAL	C	INFRARED	WRATTEN 89 B

PRINT NO. 3

PRINT EXPOSURE METHOD	TAKING CAMERA	FILM	FILTER
NORMAL	D	PANCHROMATIC	WRATTEN 25 A

Figure C-1 Imagery Taken During the Apollo SO-65 Experiment (Multispectral Terrain Photography)

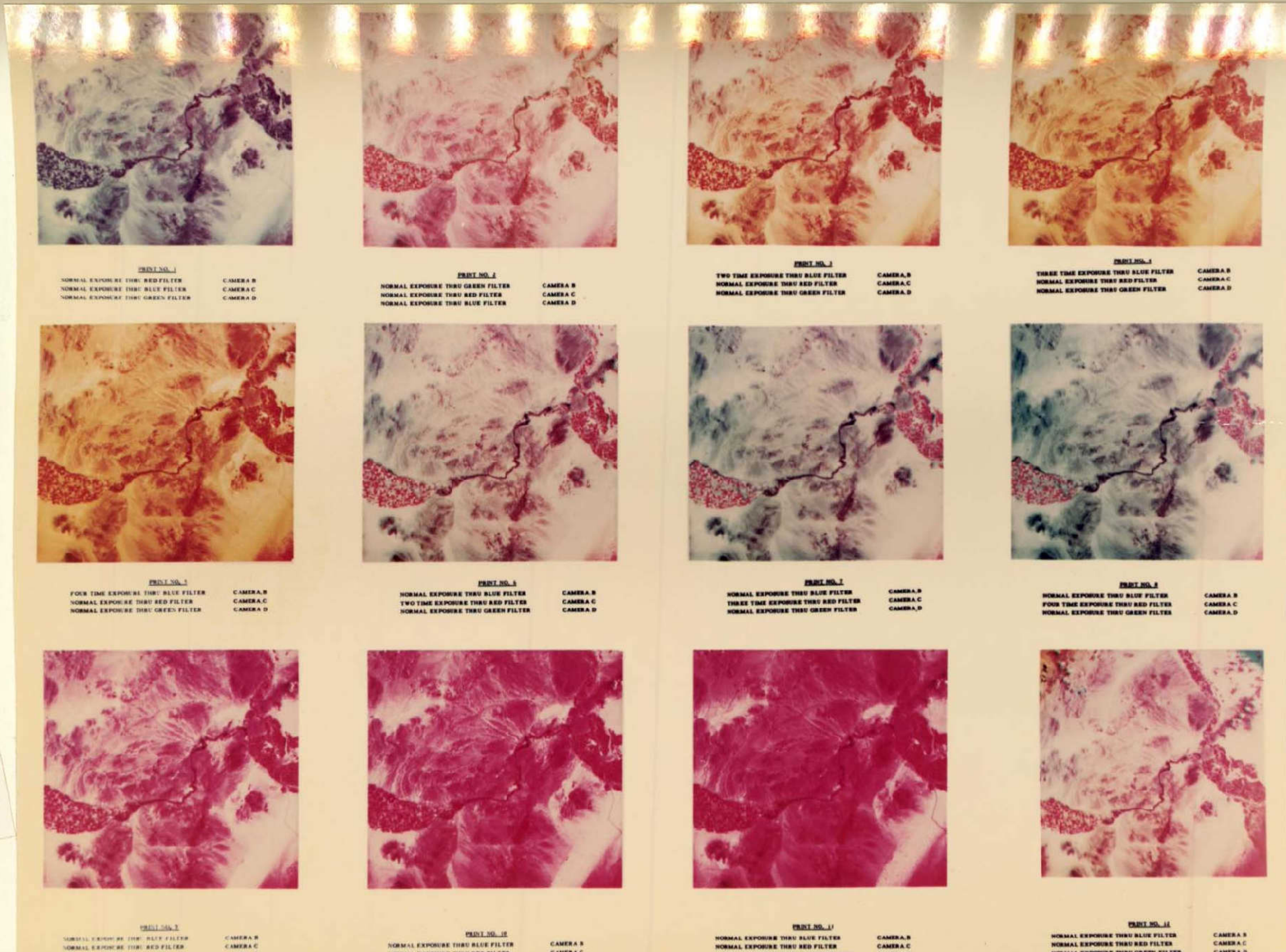


Figure C-2 Experimental Compositry Using Manual Registration and Color Filters to Obtain Various Color Composites of Imagery Taken During the Apollo SO-65 Experiment

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The black and white 70 mm negative from Camera B was placed in the negative carrier of the color enlarger and projected, to a magnification of approximately 4x, to a white surface on the easel. Major and distinguishing landmarks in the projected scene were outlined with pencil on this surface thereby providing a template to be used for further registration of the other two frames. The template was removed and a normal exposure was made through a red filter onto color-sensitized print paper. After this exposure, the template was placed back over the sensitized material. The Camera B negative was removed from the negative carrier and replaced with Camera C negative. This image was projected to the template and registered to the penciled landmark outlines. The light source was turned off, the template removed, and an exposure was then made from the Camera C negative through a blue filter. The procedure was repeated again for exposure through a green filter from the Camera D negative. The total operator time to produce one color composite approximated 15 minutes. An alternate approach to the registration of the three negatives would be to utilize a punch and pin register system. The negatives would be placed in register sequentially over a light table, then punched simultaneously at two or more locations outside the image area. A negative carrier, with pins, designed to accept the punched holes, would hold the negative in register for projection through the various filters.

C.4 Suggested Composite Projection System

Available multispectral color compositry systems have only a viewing capability with little or no emphasis on the recovery or recording mechanism required to reproduce the composite image directly on film. These systems generally offer a projected composite image on rear screen projection material which is limited in resolution, i. e., 12 to 14 lines per millimeter. Additionally, the projection devices lack the necessary control functions that would provide for accurate image registration. This projection and registration method, employed by others in the Production of Apollo-IX photography color composites (NASA Experiment SO-65), is considered to be only a fundamental approach to the color compositry.

The user and experimenter requirements of ERTS color photography will require a precision compositry system that will provide for the best quality and highest resolution color imagery that can be produced in volume. It is believed that with additional projector optical control, and recovery of the image directly on film, these requisites can be attainable.

An overall design concept is presented in the sketches shown in Figures C-3 and C-4. As shown, the system uses a projection system that will provide increased accuracy in image registration.

Figure C-3 presents a perspective view of the proposed system concept. Film magazines would be loaded with varied 9-1/2" roll film types (i.e., color negative, color positive and black and white film). The color image would be registered at a viewing plane. A rack, holding the magazines, could then be moved for exposure so that the desired film magazine is in the same plane as the viewing plane. A shutter mechanism in front of this plane would be actuated as many times as copies are needed. The film would advance automatically between exposures. This system would provide first-generation production without rear screen resolution loss. All film processing would be acomplished in roll format and would permit volume production with excellent quality control. It is believed that all control functions could be designed into a console and that an experienced operator could effect registration and production for any composite in 5 minutes or less, with additional copies being produced in 1/2 second intervals. Large production runs would reduce this time considerably.

Figure C-4a suggests a film gate design that will allow for side-to-side, up-and-down, swing-or-tilt, and $\pm$ 5° rotation adjustments.

Figure C-4b describes a front lens standard that would incorporate the same features as the film gate. These features will allow for correct lens and film relationship when the subject is not on the camera axis and will position the optics so that the plane of focus coincides with the principal plane of the subject.

Figure C-4c describes a filter wheel design. Each wheel would contain varied color Dichroic filters that could be selected and rotated in front of the lens element.

Tests indicate that the proposed approach to color compositry is valid. It is believed that a film recording system can be designed using existing viewing systems that provide imagery with minimum misregistration. Such a system could be constructed for low cost.

C.5 An Evaluation of Various False Color Displays for Natural Phenomena Detection

Figure C-2 presents several different false color displays. These false color displays generally provide an emphasis on one of the three spectral inter-

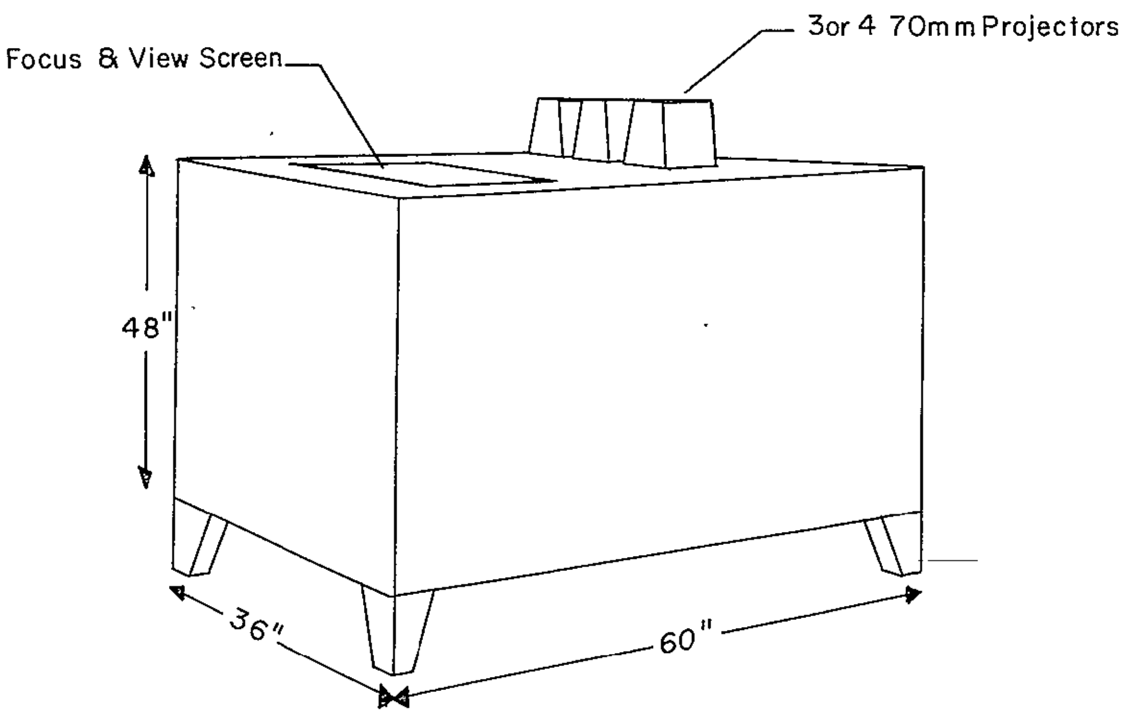

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Figure C-3 Color Compositry Film Recovery System - External Design

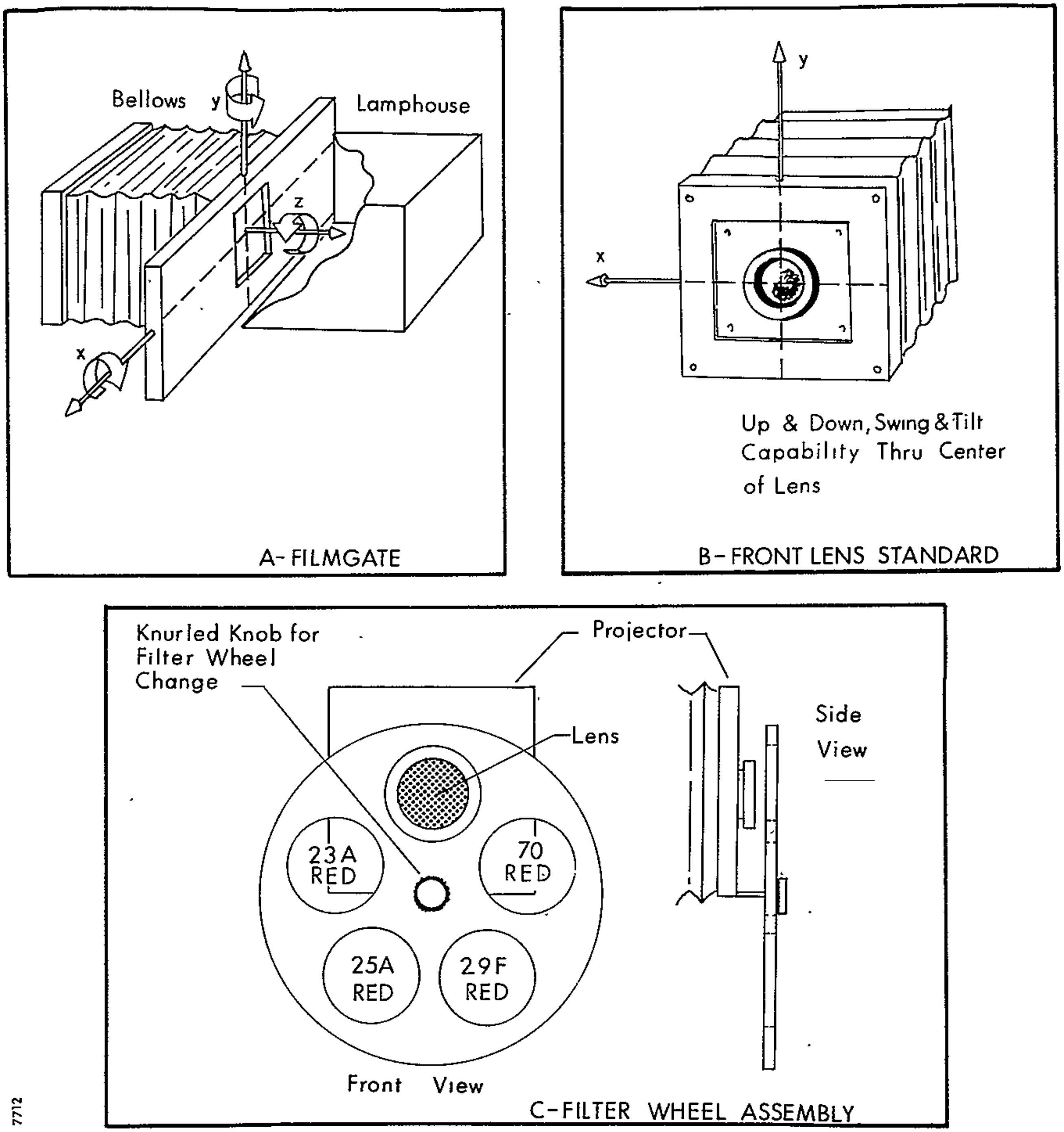

Figure C-4 Schematic of Possible Film Gate and Filter Wheel Assemblies

vals by increasing the relative exposure time through the appropriate filter. Tests are also presented where the exposure times are normal but the filter combinations have been arbitrarily changed from the normal.

The SO 65 experiment provided multispectral images in the green (Camera B), red (Camera D), and infrared (Camera C) portions of the electromagnetic (EM) spectrum. The displays are generated using blue, green, and red filters, respectively, to represent each of the original bands.

Prints 1 and 2 of Figure C-2 present the false color composites prepared by arbitrarily inverting the filters; e.g., Print 1 has a red filter on the green image, a blue filter on the infrared image and a green filter on the red image. Print 2 uses a green filter on the green image, a red filter on the infrared image and a blue filter on the red image. Print 12 is a normal IR Ektachrome (approximately) type display. Prints 3 through 5, 6 through 8 and 9 through 11 present displays providing varying amounts of emphasis on the green, red, and infrared images, respectively.

Interpretation of false color displays is generally a subjective process. One user may find one display more useful to him than another. Generally, only trial and error can yield that composite display which is most useful to a given user's needs. The following brief section will, however, present a biased estimate of the value of each display type to interpreters of various earth surface phenomena.

The scene presented in Figure C-2 covers a largely arid region containing a number of exposed rock features of both volcanic and sedimentary origin. The narrow cultivated strips present in the picture are associated with the irrigation produced by the All-American Canal, Gila River and Colorado River water-supply network. (Note: North is toward the left side of the page.) Nearly all the natural phenomena in the scene have low reflectance (relative) in the green and red. Only the cultivated fields have high (relative) reflectance in the photographic infrared.

The cultivated areas and stream channels appear to be more easily delineated on Prints 6 and 7 where the infrared reflectance is given a relative two- or three-time emphasis over the other two bands. The four-time print, i.e., Print 8, appears somewhat darker and tends to have an overall bluish cast suggesting that the utility of increased exposure for emphasis may cease at a three-time relative exposure.

Rock patterns appear to be equally well delineated in the two- or three-time green image (blue filter) composites; i.e., Prints 3 and 4, the arbitrarily inverted composite, Print 1, and the four-time relative infrared image composite, Print 8.

The generally dry drainage patterns appear most clearly in the red emphasized images (green filter), Prints 9 and, perhaps 10. This statement also appears to be valid for discrimination of sand on the basis of their different reflectances.

This brief discussion of the potential utility of a number of different color composites is quite arbitrary and certainly does not represent any user's preferance. It does appear to demonstrate that there is a requirement for more than one type of ERTS composite and potential users should be surveyed to define their preference.

C.6 Summary

ERTS color composites will form a significant part of the photographic production. If this production is to be accomplished efficiently, a projection system is a requirement. The suggested film recovery projection system discussed in this report can be largely implemented using off-the-shelf components. The suggested system should provide an efficient means to produce high-resolution first-generation color composites. The use of roll format magazines could permit volume production and permit uniformity of processing controls for a given run of color composites.

APPENDIX C

REFERENCES

Colwell, R. L., P. D. Lowman and S. Wenderoth, 1970: Apollo-9 Multispectral Photographic Information, NASA TM X-1957, Manned Spacecraft Center, Houston, Texas 77058.

APPENDIX D

GLOSSARY OF ABBREVIATIONS

AM	Annotation Monitor
ANE	Archival Negative Edit
A&S	Accounting and Sorting
CM	Calibration Monitor
DCA	Data Collation Area
DCC	Data Classification Center
DCS	Data Collection Subsystem
DCSM	Data Collection Subsystem Monitor
DER	Direct Electron Recording (film)
EBR	Electron Beam Recorder
ERTS	Earth Resource Technology Satellite
FDCD	Final Data Check/Distribution
IPA	Initial Processing and Evaluation Activity
MPR	Mosaic Preparation Area
MSS	Multispectral Scanner
NADUC	Nimbus and Applications Technology Satellite Data Utilization Center
NDPF	NASA Data-Processing Facility
PIO	Public Information Office
PPL	Photographic Production Laboratory
QA&S	Quality Assurance and Standards
QC	Quality Check
RBV	Return Beam Vidicon
USA	User Services Area
USC	User Service Center
VCM	Video Correlation Monitor